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Abstracts of Papers

Rothamsted Research

Rothamsted Research (1962) *Abstracts of Papers* ; Report For 1961, pp 248 - 289 - **DOI:**
<https://doi.org/10.23637/ERADOC-1-94>

ABSTRACTS OF PAPERS

Physics Department

GENERAL PAPERS

- 1.1. CURRIE, J. A. (1962). The importance of aeration in providing the right conditions for plant growth. *J. Sci. Fd Agric.*, **13**.
- 1.2. MONTEITH, J. L. (1960). Research on crop evaporation in Israel. (Report prepared for the Government of Israel under the United Nations Programme of Technical Assistance.)

RESEARCH PAPERS

- 1.3. CASHEN, G. H. (1961). Electric charges of clays. *Chem. & Ind.*, 1732-1737.

Kaolin possesses an isomorphous replacement charge, and develops additional negative and positive charges in alkaline and acid conditions respectively. The residual positive edge charge after washing is small, and because exchangeable aluminium is always found, the kaolin decomposes when the edges discharge. Illites and montmorillonites behave similarly. After an acid/water treatment of clay minerals the action of deflocculants is primarily to replace exchangeable aluminium and not to neutralise positive edge charges.

- 1.4. CURRIE, J. A. (1961). Gaseous diffusion in the aeration of aggregated soils. *Soil Sci.*, **92**, 40-45.

Adequate aeration depends partly on active soil depth and a macro-diffusion coefficient, and partly on micro-structure and diffusion within crumbs. Formal analysis of the diffusion problem is based on three assumptions: (i) that the soil has a crumb structure, *i.e.* that there are inter-crumbs channels permitting aeration of the soil matrix as a whole; (ii) that respiratory activity is uniform throughout the crumb; and (iii) that there is a single critical concentration at which all aerobic activity ceases in all organisms.

The analysis gives some idea of the physics of "optimum crumb size". The lower limit is set by the minimum inter-crumbs pore size that will permit free drainage at field capacity. The upper limit is set by potential respiration of the soil and by the structure of the crumbs and their water content. No universally acceptable specification of optimum size is possible.

- 1.5. MONTEITH, J. L. (1962). Dew: facts and fallacies. In *Water Relations of Plants*. British Ecological Society.

The maximum or "potential" condensation rate on a horizontal surface of negligible heat capacity, realised when the atmosphere is saturated, is independent of wind speed and is directly proportional to net radiative loss, R . The constant of proportionality is temperature dependent and, assuming an empirical expression for R , calculated potential condensation is 0.067 ± 0.007 mm./hr. between 0° and 25° , with a maximum at 12° . In slightly unsaturated air condensation falls below the "potential" value by an amount depending on relative humidity and wind speed. Theoretical values are consistent with measurements at Rothamsted and elsewhere, but much larger values, physically impossible, are found in the literature.

Maximum condensation on artificial dew gauges reached 0.4 mm./night, apparently irrespective of climate. When dew gauges have approximately the same thermal properties as leaves and are exposed close to the crop canopy they may give useful estimates of dew amount and duration when the atmosphere is saturated. Potential condensation on non-horizontal bodies such as isolated trees and shrubs can be found from the effective radiative loss,

and is always greater than the potential condensation on a horizontal surface with the same projected area. The closed canopy of a field crop collects approximately the same dew as an equivalent projected surface.

Two transfer processes for condensation are "distillation" (quasi-molecular diffusion of water vapour from warm soil to cooler leaves) and "dewfall" (turbulent transfer of vapour from atmosphere to leaves). In a saturated atmosphere the dewfall/distillation ratio depends on the relative thermal properties of atmosphere and soil, effectively on wind speed. On a calm, clear night dewfall is negligible; with a light wind, dewfall may exceed distillation; with a high wind, leaves do not cool sufficiently for dew to form. Dewfall conserves soil moisture; distillation accelerates its loss.

Dry soil can absorb water vapour directly from the atmosphere, but this water is not "available" to plant roots. The absorption of vapour by leaves has been demonstrated in the laboratory; in nature, the absorption of dew is more important. This absorption decreases water deficits and prolongs plant life when soil moisture is critically low. It may also stimulate growth, but conclusive field evidence is lacking. Without absorption, dewfall can lower transpiration in the early morning but cannot protect plants from severe water stress throughout the day.

- 1.6. MONTEITH, J. L. & SZEICZ, G. (1962). Simple devices for radiation measurement and integration. *Arch. Met., Wien*, B12.

Simple thermopiles formed by copper-plating a constantan wire were used to build a solarimeter and a net radiometer. Output was 5–10 mV/cal. cm.⁻² min.⁻¹, adequate to operate a small portable galvanometer for spot readings, a continuously recording potentiometer or, for integration, a Siemens electrolytic meter. The net radiometer was unventilated, but when oscillated manually, output was independent of wind speed. With two solarimeters in a null-balance circuit, reflection and transmission coefficients of a field crop were read directly on a dial. The Siemens meter had a back E.M.F. of about 350 μ V and a temperature coefficient of resistance of $-2.5\%/^{\circ}$ C. A circuit was designed to integrate solarimeter output and the standard error of weekly readings was only ± 40 cal./cm.².

- 1.7. PENMAN, H. L. (1961). Weather, plant and soil factors in hydrology. *Weather*, 16, 207–219.

The components in the water balance of a catchment area are discussed, with some detail on the separation of stored water from soil water. The evaporation term is considered both energetically and aerodynamically, and a new combined general formula is given, thought to be applicable to any kind of surface. Examples used and discussed are: comparison of transpiration from papyrus and evaporation from open water (Sudan); comparison of irrigated and non-irrigated herbage (Congo); the water balance of a British catchment over 15 years (Stour); and comparison of evaporation from grass and forest (Germany). None of the three comparisons reveals any major difference in evaporation rates—the local climate is dominant.

- 1.8. PENMAN, H. L. (1962). Physical properties of soils. In "The Soil". Symposium of Institutes of Biology, Chemistry & Physics, March 1961.

Soil properties are in three groups: particle properties (texture), pore properties (structure) and quasi-homogeneous properties. The interactions of texture and structure are discussed in terms of available water, soil structure and stability, and aeration. At field capacity the "available water" should be as large as possible to permit maximum resistance to drought, and the crumbs that hold this water must be small enough to ensure that what is defined as available is also accessible, and to avoid risk of anaerobic conditions. Good management may open the soil, beneficially, but the slowness of return to closer packing depends on crumb stability.

- 1.9. PENMAN, H. L. (1962). Woburn Irrigation 1951–1959. Part I. Purpose, design and weather. Part II. Results for grass. Part III. Results for rotation crops. *J. agric. Sci.*, 58,

An extended summary of the agronomic results in these three papers was given in the main report for 1960, pp. 33–38.

- 1.10. ROSE, D. A. (1962). The effect of dissolved salts on water movement. In *Water Relations of Plants*. British Ecological Society.

Experiments confirm theoretical prediction that the presence of solutes decreases the diffusion rate of water, the decrease being proportional to the solute concentration and inversely proportional to the diffusion coefficient of the solute ions in the porous system. There seems no serious risk that the osmotic potential gradient set up by the presence of soil fertilisers will successfully compete with the plant roots in drawing water out of the region between them.

- 1.11. SCHOFIELD, R. K. & TAYLOR, A. W. (1961). A method for measurement of the calcium deficit in saline soils. *J. Soil Sci.*, **12**, 269-275.

The calcium deficit of a saline soil is defined as the amount of calcium which must be supplied to saturate the soil with divalent cations. A method is described whereby this amount can be measured in samples of unwashed saline soil and used to estimate the amount of gypsum needed in the field to prevent deterioration of the soil structure while it is being leached into a salt-free condition.

Chemistry Department

GENERAL PAPERS

- 2.1. BARROW, N. J. (1961). Phosphorus in soil organic matter. *Soils & Fert.*, **24**, 169-173.
- 2.2. COOKE, G. W. (1961). Soils and Fertilisers. *J. R. agric. Soc.*, **122**, 150-174.
- 2.3. COOKE, G. W. (1960). Field experiments on phosphate fertilisers in the United Kingdom. *Proc. Third int. Congr. int. Ass. Res. Phosphates*, pp. 150-154.
- 2.4. COOKE, G. W. (1960). Recent research on the value of phosphate reserves in soils. *Proc. Third int. Congr. int. Ass. Res. Phosphates*, pp. 184-191.
- 2.5. COOKE, G. W. (1961). The use of nitrogen fertilisers in Britain and their effects on the yield and composition of crops. *Agrochimica*, **5**, 189-206.

RESEARCH PAPERS

- 2.6. ARNOLD, P. W. & CLOSE, B. M. (1961). Release of non-exchangeable potassium from some British soils cropped in the glasshouse. *J. agric. Sci.*, **57**, 295-304.

Continuous cropping with perennial ryegrass in the glasshouse measured the release of non-exchangeable potassium from twenty soils representative of a wide variety of soil series. Releases of non-exchangeable K ranged from almost none to >2,000 lb. K/acre. The main reason for variations in the potassium-releasing powers of the soils was traced to differences in the amount and K content of the finer clay fractions. Small K-contents in the fine clay, and small contents of fine clay, were associated with small releases of non-exchangeable K. Accumulated potash fertiliser residues, or the presence of such minerals as glauconite, can be responsible for the good potassium-releasing powers of some soils. Many soils appear to contain at least two categories of useful non-exchangeable K.

- 2.7. ARNOLD, P. W. & CLOSE, B. M. (1961). Potassium-releasing power of soils from the Agdell rotation experiment assessed by glasshouse cropping. *J. agric. Sci.*, **57**, 381-386.

On cropping Agdell experiment top-soils to exhaustion with perennial ryegrass in the glasshouse, the total K uptakes were directly proportional to the initial exchangeable K contents of the soils. The ability of the Agdell top-

soils to release non-exchangeable K under glasshouse conditions decreased in the order PK-rotation with fallow > NPK-rotation with fallow > PK-rotation with clover > NPK-rotation with clover > no-fertiliser-rotation with fallow = no-fertiliser rotation with clover. Releases of non-exchangeable K were at least 2.5 times larger than the falls in the exchangeable K for all the Agdell soils. In a "take-down" experiment in the glasshouse on a soil receiving K fertiliser each year in the Saxmundham Rotation I Experiment, loosely held non-exchangeable K was released at a near-linear rate. At least a part of the loosely held non-exchangeable K in the Agdell soils was also released at a near-linear rate.

- 2.8. CHAKRAVARTI, S. N. & TALIBUDEEN, O. (1961). Phosphate interaction with clay minerals. Part I. Effects of a 10^{-5} molar phosphate solution on two and three layer minerals at pH values 3, 4 and 5. *Soil Sci.*, **92**, 232-242.

Hydrogen-ion uptake from solution at pH values 3, 4 and 5 by two 1:1-type and two 2:1-type clay minerals was measured over 9 months with and without the addition of a 10^{-5} M-potassium phosphate solution. Approximately linear relationships were observed between nett proton uptake (N.P.U.) and time at each pH level, and between $-\log$ (N.P.U.) and the pH of the system at any sampling time, whereas phosphate uptake and N.P.U. were unrelated. However, the N.P.U. per g. per year was much larger in the phosphate systems at the higher pH values, where adsorbed $H_2PO_4^-$ ions significantly increased the hydrogen-ion activity in the electrical double layer. The total surface area of the minerals was only very qualitatively related to their N.P.U./g./year. The dimensions of platelets in the two kaolinites and the glauconite laths are discussed with respect to phosphate uptake in the pH range 3-5, assuming that N.P.U. is primarily due to "octahedral edge-face" area. Linear relationships were invariably observed between $-\log$ (M^{3+}) and pH, where M = Al or Fe. A polymeric chain model of variable length is proposed for cations of aluminium adsorbed on the octahedral edge faces of the minerals containing 17 atoms of the metal for the kaolinite and glauconite and 4 atoms for the montmorillonite. Corresponding figures for the iron polymeric ion are 8 and 1 respectively.

- 2.9. GASSER, J. K. R. (1961). Transformation, leaching and uptake of fertiliser nitrogen applied in autumn and spring to winter wheat on a heavy soil. *J. Sci. Fd Agric.*, **12**, 375-380.

The concentrations of ammonium and nitrate in the surface layer (0-6 inches) of a heavy soil with and without fertiliser-N were measured from October 1957 to September 1958 on plots growing winter wheat and in bare soil. Ammonium sulphate or calcium nitrate supplying 100 lb. of N/acre was applied in the autumn, in the spring or half in autumn + half in spring. Both forms of fertiliser applied in the autumn were lost from the surface soil by the following March. Autumn-applied nitrogen was not taken up by the wheat during the autumn or winter. Nitrogen applied in the spring was rapidly taken up by the crop, but remained in the surface soil of the bare plots until June, when prolonged and heavy rain leached the nitrate into the lower soil layer. At the time the ears emerged much more mineral nitrogen had been lost from the soil top-dressed with fertiliser in the spring than was accounted for by the increase in nitrogen uptake by the above-ground parts of the wheat. The yields of grain and straw at harvest were not increased by the nitrogen fertilisers, whenever applied. The nitrogen contents of both grain and straw were increased by applying fertilisers, and there were consistent but small increases in the total nitrogen uptake by the wheat on the fertilised plots. The uptake of fertiliser nitrogen was greatest in the samples taken at ear emergence when, on average, 27 lb. of N/acre of the 100 lb. applied were recovered. At harvest wheat from the fertilised plots contained 18 lb. of N/acre less than at ear emergence.

- 2.10. GASSER, J. K. R. (1961). Soil nitrogen. VI. Correlations between laboratory measurements of soil mineral-N and crop yields and responses in pot and field experiments. *J. Sci. Fd Agric.*, **12**, 562-573.

Soil samples from sites of field experiments testing N-fertilisers for barley, potatoes, kale and grass were used for pot experiments with ryegrass and also

to measure "available"-N in the laboratory. Mineral-N in the fresh soil (Mineral-N_{fresh}) and the increases when fresh or re-wetted air-dry soils were incubated (Δ Mineral-N_{fresh} or Δ Mineral-N_{air-dry}) were determined. These were more highly correlated with organic C than with total N content of the soils. Among "available"-N measurements, Mineral-N_{fresh} and Δ Mineral-N_{air-dry} were most correlated with one another. The yields of dry matter and N uptake of ryegrass grown in unfertilised soil, or with two rates of applied N, were significantly correlated with Mineral-N_{fresh} or Δ Mineral-N_{air-dry} at each level of nitrogen, but not with Δ Mineral-N_{fresh}.

The unfertilised yields of barley in field experiments were significantly correlated with Mineral-N_{fresh}, Δ Mineral-N_{air-dry}, and total N; responses by barley to 0.5 cwt. of N/acre were significantly negatively correlated with all three "available"-N measurements and with total N. Unfertilised yields of potatoes were significantly correlated with the three "available"-N measurements and responses to 1.0 cwt. of N/acre were significantly negatively correlated with Δ Mineral-N_{air-dry} and total N. Mineral-N_{fresh} and Δ Mineral-N_{air-dry} are suggested as useful measurements for advisory purposes.

- 2.11. GASSER, J. K. R. (1961). Effects of air-drying and air-dry storage on the mineralisable-nitrogen of soils. *J. Sci. Fd Agric.*, **12**, 778-784.

Samples of eight soils were air-dried and stored in brown-paper or in sealed polythene bags for periods up to 98 weeks. Portions of the fresh and re-wetted air-dry soils were incubated at 25° for 10-84 days. The soils were extracted before and after incubation and the increase in mineral-N (NH₄⁺-N + NO₃⁻-N) content (Δ Mineral-N) was measured. Air-drying increased Δ Mineral-N. Air-dry storage further increased Δ Mineral-N, the value increasing with the period stored, but the mineralisable-N of soils kept in sealed polythene bags increased less than that of soils in paper bags, the increases occurring only in the easily mineralisable-N; most of the extra mineral-N was formed during the first 10 days' incubation, and all by 42 days; thereafter the air-dried soils had the same rate of mineralisation as the fresh soils. The mineral-N content of the air-dry soils increased with storage. In a further similar test with fourteen soils, air-dried and stored in brown-paper bags for periods up to 32 weeks, the mean value of Δ Mineral-N varied irregularly with time of storage up to 18 weeks, but thereafter increased with increasing period of storage before incubation. The mineral-N content of the air-dry soils varied, the maximum value being found in the samples stored for 12 weeks.

- 2.12. HEINTZE, S. G. (1961). Studies on cation-exchange capacities of roots. *Plant & Soil*, **13**, 365-383.

Enzymic breakdown of pectin caused an initial rapid pH drift towards the acid side when hydrogen-ion-saturated roots were neutralised. Buffer curves of root suspensions showed that at least some of the acidic groups of root surfaces are derived from carboxylic groups of pectin acid. Roots showed greater affinity for Ba⁺⁺ than for K⁺-ions at concentrations below normality. Estimations of CEC values from exchange reactions between roots and the latter cations were more affected by altering the conditions during exchange than were those from exchange with Ba⁺⁺. Isotopic exchange between roots saturated with non-labelled calcium and Ca⁴⁵ suggested that adsorbed calcium is held in an exchangeable and not in chelated form. Changes in CEC caused by ageing of plants, or by varying nutrient levels in the growing medium, agreed in general, both in direction and magnitude, with the findings of other workers. High CEC values were associated with low K/Ca ratios of plant tops or of the whole plant, and *vice versa*, when comparisons were restricted within the same K-level of the growing medium. This relationship was reversed for CEC values and K/Ca ratios of roots of clover and ryegrass. A correlation coefficient that was just significant was found in some comparisons for the relationship between CEC values of two species and the inverse ratio of the K-contents of their tops.

- 2.13. JENKINSON, D. S. (1960). The production of ryegrass labelled with carbon-14. *Plant & Soil*, **13**, 279-290.

The construction and operation of a growth chamber for producing plant material labelled with carbon-14 to a specified degree of uniformity is described.

The specific activity of the plant material is measured by a method based on scintillation counting.

- 2.14. MATTINGLY, G. E. G. & PINKERTON, A. (1961). Some relationships between isotopically exchangeable phosphate, soil analysis and crop growth in the greenhouse. *J. Sci. Fd Agric.*, **12**, 772-777.

An experiment on perennial ryegrass in small pots compared yields of grass and responses to added superphosphate with the analyses of fifteen soils and with their total isotopically exchangeable phosphate ("A" value). The highest positive correlations between yields, and negative correlations between responses to added superphosphate, were obtained with "A" values. The phosphate extracted by 0.5M-NaHCO₃, 0.5N-acetic acid-sodium acetate, 0.3N-HCl and 0.002N-H₂SO₄ (reagents 1-4, respectively) also correlated well with yield. Yield and phosphate soluble in 0.5N-acetic acid (reagent 5) were not significantly correlated. The soils were mixed with ³²P-labelled superphosphate, stored for 30 days at field moisture capacity, air-dried and extracted with the five reagents listed above. The amounts of ³²PO₄ that exchanged with soil phosphate during extraction were compared with the amounts that exchanged in soil similarly treated and cropped with ryegrass in the greenhouse. More soil phosphate exchanged during extraction with reagents 3-5 in the laboratory than in the greenhouse experiment. These reagents dissolved soil phosphate, or exposed new surfaces on the soil, from which phosphate is not taken up by ryegrass. The soil phosphate that exchanged in reagents 1 or 2 was more closely correlated with, and nearly equal to, the "A" value of the soils enriched with superphosphate. Reagent 1 did not increase soil phosphate surfaces in most soils, but reagent 2 dissolved some phosphate, which did not exchange in the greenhouse, from soils containing more than 4% CaCO₃.

- 2.15. NOWAKOWSKI, T. Z. (1961). The effect of different nitrogenous fertilisers, applied as solids or solutions, on the yield and nitrate-N content of established grass and newly-sown ryegrass. *J. agric. Sci.*, **56**, 287-292.

Experiments on permanent grass and newly-sown Italian ryegrass compared ammonium hydroxide solution, with ammonium sulphate, ammonium nitrate, calcium nitrate and urea, applied at 56 and 112 lb. N/acre as solids, and also when dissolved in water to give a final N content of 5%. Ammonium hydroxide solution containing 5% N damaged established grass severely and did not increase dry-matter yields; when applied to the seedbed before sowing Italian ryegrass, ammonium hydroxide solution did not affect germination, but yields were lower than with other N fertilisers. On permanent grass all other fertilisers significantly increased dry-matter yields and N uptake at both cuts. The form of N fertiliser did not significantly affect dry-matter yields or N uptake of grass of the first cut. The method of application (i.e., solid or liquid) did not affect dry-matter yields, except that ammonium nitrate in solution gave a significantly higher yield than did the solid form at the second cut; the grass had higher N content with solid forms than with solutions. The grass took up more N from solid forms than from solutions except with ammonium nitrate at the second cut. Delaying the N application by 20 days decreased dry-matter yields considerably and increased the N content of the grass. In the experiment with newly-sown Italian ryegrass all fertilisers significantly increased dry-matter yields and N uptake at both cuts. Dry-matter yields of the first cut were significantly higher with calcium nitrate than with all other fertilisers. The dry-matter yields of the second cut obtained with calcium nitrate, ammonium nitrate and urea did not differ significantly; the yield with ammonium sulphate was significantly lower than that with calcium nitrate and ammonium nitrate, but was not significantly lower than the yield with urea. The differences in N taken up by plants from different fertilisers were in the order: calcium nitrate > ammonium nitrate > urea > ammonium sulphate. More N was taken up from solid forms than from solutions.

The grass which received 56 lb. N/acre contained little nitrate, and differences between treatments were small. The nitrate content of grass receiving 112 lb. N/acre depended on the form of the fertilisers and the time and method

of application. Nitrate contents were highest with calcium nitrate (1,384 p.p.m.) or ammonium nitrate (1,418 p.p.m.), lowest with ammonium sulphate (386 p.p.m.) and intermediate with urea (724 p.p.m.). The nitrate content of permanent and new-sown grass was greater with solid fertilisers than with solutions. Delaying the application of fertiliser increased the amount of nitrate in the grass.

- 2.16. WIDDOWSON, F. V. & PENNY, A. (1960). Experiments with urea on spring barley. *Exp. Husbandry*, No. 5, 22-26.

Four spring barley experiments compared combine-drilled dressings of urea and ammonium sulphate supplying 0.25, 0.5 or 0.75 cwt. N/acre. Urea was consistently inferior to ammonium sulphate. Urea supplying 0.5 cwt. N/acre checked early growth; at 0.75 cwt. N/acre urea checked growth severely and some plants died. These checks occurred at each centre, but their effects were less, in terms of yields at harvest, with very early sowing. Ammonium sulphate checked growth slightly at the heaviest rate of application. The nitrogen percentages of grain grown with urea or ammonium sulphate were similar with dressings of 0.25 or 0.50 cwt. N/acre, but with dressings of 0.75 cwt. N/acre, urea gave grain containing more nitrogen.

- 2.17. WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1961). Applying nitrogen fertilisers for spring barley. *J. agric. Sci.*, 56, 39-47.

Fifteen experiments on spring barley (mainly Proctor) done from 1957 to 1959, compared alternative methods of applying 0.3, 0.6 and 0.9 cwt. N/acre. Combine-drilling 0.3 or 0.6 cwt. N/acre as ammonium sulphate produced higher mean yields than broadcasting, but drilling 0.9 cwt. N/acre checked early growth and reduced mean yields in two of the three seasons. Supplementing 0.3 cwt. N/acre by combine-drill with an equivalent top-dressing of "Nitro-Chalk" consistently outyielded a single drilled or broadcast dressing supplying the same total quantity of N. Supplementing the heavier drilled dressing (0.6 cwt. N/acre) with 0.3 cwt. N/acre top-dressing was less advantageous, and yields were depressed in the wet season of 1958. Gains from N fertilisers were recorded at every centre. Dressings in excess of 0.6 cwt. N/acre gave only small gains in yield and caused severe lodging in 1958. The experiments support our previous work on local soils, in which 0.5-0.6 cwt. N/acre was optimum for barley. The N content of barley receiving no N fertiliser ranged from 1.52 to 2.16%, with a mean value of 1.70%. A seedbed dressing of 0.3 cwt. N/acre had little effect on N content and decreased values at several centres; heavier dressings gave appreciable gains in N content. All dressings of N increased the proportion of small grains; top-dressings gave more small grains than broadcasting; drilling gave samples of intermediate value.

- 2.18. WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1961). Experiments with nitrogen and potash on barley. *J. agric. Sci.*, 57, 29-33.

Four experiments in 1958 and five in 1959 compared responses to K (as combine-drilled muriate of potash) in the absence of N and in the presence of single and double doses of N (as broadcast ammonium sulphate) on soils low in acid-soluble K. Responses to 0.5 cwt. K₂O/acre were obtained at 6 centres (2 significant), but the effects of a further 0.5 cwt. K₂O/acre varied more, and gains and losses (each at 4 centres) were almost equally balanced. Gains from N were associated with previous cropping. N₁ raised yields at 7 centres (6 significantly) but N₂ raised yields further at only 5 centres (3 significantly) and depressed yields significantly at 3 centres where barley followed roots or ley. Potash did little to improve strength of straw and standing capacity in a wet season (1958) and had little effect on size of grain, whereas N increased lodging and decreased average size of grain. Increases in K uptake were associated with yield increases, whereas increases in N uptake were associated with both higher N percentage in grain and higher yields.

- 2.19. WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1961). Autumn nitrogen for winter wheat. *J. agric. Sci.*, **57**, 329-334.

Fourteen experiments with winter wheat on heavy-land farms from 1958 to 1960 compared autumn dressings of ammonium sulphate with equivalent early (March) or late (May) spring top-dressings. Dressings applied on two or all three dates of application were also compared. Consistent and significant gains in yield from low (0.5 or 0.6 cwt. N/acre) and high (1.0 or 1.2 cwt. N/acre) levels were obtained at most centres, which were on fields under arable rotation. With the low level of N, gains in yield were greatest from a single May top-dressing. There was no gain from dividing the dressing. With the high level of N, dressings divided between autumn-May or March-May were best. March-May was the most consistently satisfactory treatment and gave the highest mean increases in yield in 1959 and 1960, but in 1958 autumn-May was better. Single May dressings gave slightly lower yields. There was no advantage from dividing N between all three dates of application. Single applications of N in autumn gave lower yields than single applications in spring; supplementing autumn N with a late spring top-dressing gave almost the same yield as giving all the N in spring. The percentage of N in the grain was highest with a late top-dressing of fertiliser-N, lowest with autumn N and intermediate with March top-dressings.

- 2.20. WILLIAMS, R. J. B. & COOKE, G. W. (1961). Some effects of farmyard manure and of grass residues on soil structure. *Soil Sci.*, **92**, 30-39.

Clay and sandy soils that had contrasted continuous treatments were used in laboratory measurements of pore sizes, of aggregate stability and permeability, and of clod strengths. Thin sections showed close packing occurred in natural aggregates of sandy soils under continuous arable cultivation; sands were improved by farmyard manure (FYM) or by grass roots, and all the clay soils tested had some large pores. Pore-size measurements showed that checks to root growth were unlikely with the clays used, but were possible with the arable sands. A simple and quick practical test was developed to identify soils where unstable structure may lead to poor crops. The percentage loss in pore space that occurred after twice wetting and draining an aggregated soil sample measured structural instability, such as may lead to close packing in wet weather; the rate water passed through soil after the slaking test measured permeability and indicated whether trouble may be expected from small pores in packed soil. Continuous grass was more effective than annual dressings of FYM in making soils more permeable, in making aggregates stable to water, and in weakening clods formed by mechanical ill-treatment. Sandy soil under continuous arable cultivation without FYM gave very unstable aggregates and packed badly after slaking, but FYM given once in 5 years improved stability and permeability only slightly. Six months after sowing grass the sandy soil was much more stable, but still packed badly; 3 years under grass stabilised structure completely, but most of the improvement was lost a year after ploughing. For high yields of arable crops on soils that are unstable and poorly permeable, more organic matter may be needed than is given by the residues of arable crops grown on the land; the extra organic matter is better provided by a period under grass than by occasional dressings of FYM.

Pedology Department

BOOK

- 3.1. BROWN, G. (1961). *The X-ray identification and crystal structures of clay minerals*. Edited by G. Brown. 2nd edition. London: Mineralogical Society.

GENERAL PAPERS

- 3.2. MUIR, A. (1961). The podzol and podzolic soils. *Advanc. Agron.*, **13**, 1-56.

- 3.3. NG SIEW KEE & BLOOMFIELD, C. (1961). Mobilisation of trace elements in waterlogged soils. *Chem. & Ind.*, 252-253.

RESEARCH PAPERS

- 3.4. NG SIEW KEE & BLOOMFIELD, C. (1961). The solution of some minor element oxides by decomposing plant materials. *Geochim. et cosmoch. Acta*, **24**, 206-225.

Oxides of several trace elements are dissolved by the action of anaerobically fermenting plant material and, less effectively, by sterile aqueous extracts of undecomposed plant material. The dissolved metals seem to be in complex form, not colloiddally dispersed. The solutions are stable to atmospheric oxidation, but in the presence of ferrous iron aeration causes co-precipitation of the trace elements with ferric oxide. The order of ease of co-precipitation appears to be Mo, V > Zn > Cu > Co > Ni. Sorption on ferric oxide is appreciable in some conditions. Copper and nickel are irreversibly sorbed from fermentation solutions by plant fibre.

- 3.5. WEIR, A. H., NIXON, H. L. & WOODS, R. D. (1962). The measurement of dispersed clay flakes with the electron microscope. *Clays and Clay Minerals*. London: Pergamon Press, pp. 419-423.

The shadow lengths of dispersed flakes of the layer-lattice mineral, allevardite, were measured with the electron microscope. Details of the experimental technique are given, and the importance is stressed of using samples free from very small material. The measurements of flake thickness agreed well with estimates of the basal spacing of the collapsed lattice obtained by X-ray diffraction analysis, and dispersion of allevardite produced suspended flakes 19 Å thick, corresponding in thickness to the basic structural unit of two 2 : 1 layers.

Soil Microbiology Department

GENERAL PAPERS

- 4.1. BROWN, M. E. & COOPER, R. (1960). Microbiology of the soil. *Rep. Progr. appl. Chem.*, **45**, 551-568.
- 4.2. MOSSE, B. (1962). Vesicular-arbuscular mycorrhiza and some problems associated with their study. [In Italian] *Nuovo G. bot. ital.* (In the press.)

RESEARCH PAPERS

- 4.3. BROWN, M. E., BURLINGHAM, S. K. & JACKSON, R. M. (1962). Studies on *Azotobacter* species in soil. 1. Comparison of media and techniques for counting *Azotobacter* in soil. *Plant & Soil*. (In the press.)

The highest counts of *Azotobacter* were obtained from soil suspensions shaken in sterile distilled water containing 10 g. glass beads and plated on to glucose agar. Mannitol was rejected as a suitable substrate in agar media because it gives lower counts of *Azotobacter* than glucose, an effect further enhanced by drying the agar plates. A clear medium free from precipitated phosphate and CaCO₃ is recommended for the agar-plate method; the *Azotobacter* count is affected by the phosphate concentration.

The dilution-tube method is less accurate than the agar-plate, but more convenient when many soil samples have to be examined.

- 4.4. LJUNGGREN, H. (1961). Transfer of virulence in *Rhizobium trifolii*. *Nature, Lond.*, **191**, 623.

An avirulent (non-nodulating) strain of clover nodule bacteria (Strain Bart. A) was induced to form nodules on white clover by treatment with a cell-free preparation made from an unrelated virulent strain (Strain 226).

Bacteria isolated from nodules produced by the changed strain retained their virulence after subculture, without further treatment. Neither the avirulent mutant strain (which was rough) nor its smooth virulent form after treatment agglutinated with an antiserum made against a related virulent strain (Strain A121111). Both the changed strain and the strain providing the inducing preparation required pantothenic acid, whereas the avirulent mutant did not. These results suggest that the change in virulence is a genetic transformation mediated by DNA present in the cell-free preparation.

4.5. MEIKLEJOHN, J. (1962). Microbiology of the nitrogen cycle in some Ghana soils. *Emp. J. exp. Agric.* (In the press.)

The bacteria concerned in the nitrogen cycle were counted in Ghana forest and grassland soils. These two types of vegetation produce very different levels of soil fertility. The forest soils are very fertile, with a high content of exchangeable bases, organic matter and nitrogen. Grassland soils are much less fertile, and lack available nitrogen.

The forest and grassland soils differ little in their content of nitrogen fixers; the numbers are generally high, and slightly higher in grassland soils. Anaerobic nitrogen fixers (Clostridia) were always present. Of the aerobic nitrogen fixers, *Azotobacter* was dominant in neutral soils and *Beijerinckia* in acid soils. Cells of *Azotobacter* and *Beijerinckia* were found on the leaves of forest plants.

Forest and grassland soils contain very different numbers of nitrifiers. As long as soil cover is maintained, forest soils contain many ammonia- and nitrite-oxidisers, whereas grassland soils contain few ammonia-oxidisers and very few or no nitrite-oxidisers. None of the grassland samples taken after the start of the rainy season contained any nitrite-oxidisers. The lack of available nitrogen in Ghana grassland soils seems mainly because there are no bacteria able to oxidise nitrite to nitrate.

4.6. MOSSE, B. (1962). The establishment of vesicular-arbuscular mycorrhiza under aseptic conditions. *J. gen. Microbiol.*, **27**, 509-520.

The establishment of vesicular-arbuscular mycorrhizal infections by inoculation with germinated resting spores of an *Endogone* species was investigated under microbiologically controlled conditions; pure two-membered cultures were obtained for the first time.

Seedlings were grown in a nitrogen-deficient inorganic salt medium, and under these conditions the fungus was unable to form an appressorium and to penetrate the plant roots unless an inoculum of a *Pseudomonas* sp. was also added. Adding soluble nitrogen to the medium completely inhibited root penetration, even in the presence of the bacteria. Various sterile filtrates could be used to replace the bacterial inoculum, but these induced only few infections per plant.

Mycorrhizal roots grew more vigorously than non-mycorrhizal roots of the same seedling. They were longer and more profusely branched. At first mycorrhizal infections were predominantly arbuscular, but many prominent vesicles developed as the seedlings declined, and then the fungus grew out of infected roots and colonised the agar. The fungus could not be subcultured without a living host.

4.7. NUTMAN, P. S. (1962). The relation between root hair infection by *Rhizobium* and nodulation in *Trifolium* and *Vicia*. *Proc. roy. Soc.* (In the press.)

The infection of the root-hairs of young seedlings of twelve species of *Trifolium* and of *Vicia hirsuta* was examined. The amount of infection (numbers of hairs containing infection-threads) at 2 weeks varied much between species of host, and was less affected by bacterial strain; host and strain differences were independent. In most hosts a high proportion of infections did not result in nodule formation.

The relative rates of increase in numbers of infected hairs was constant before nodulation began. The duration of this pre-nodulation phase of exponential increase in infection, but not its rate, differed between species. Nodulation (and lateral root formation) caused an abrupt lowering of the

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initial rate of infection. Post-nodulation infection also increased exponentially. Low concentrations of nitrate nitrogen delayed nodulation and increased the numbers of hairs infected.

Infected hairs were not randomly distributed along the root, infection beginning at a few well-separated points. Later infections occurred near these primary foci to give zones of infection, which then spread up and down the root. The positions of nodules or lateral roots were not related to the foci of hair infection.

Botany Department

RESEARCH PAPERS

- 5.1. HUMPHRIES, E. C. (1961). Effects of quality of light on development of roots on dwarf bean hypocotyls in presence and absence of boron. *Nature, Lond.*, **190**, 701-703.

The effect of boron on root formation on hypocotyls of dwarf French bean was influenced by the quality of light received by the plant. Incandescent light given before or after the hypocotyls were excised decreased the number and weight of adventitious roots on plants without boron, but had no effect on root formation of plants given boron. Plants in fluorescent light produced similar numbers of roots whether boron was supplied or not.

- 5.2. HUMPHRIES, E. C. & FRENCH, S. A. W. (1961). Effect of nitrogen supply on the response of Majestic potato to gibberellic acid. *Ann. appl. Biol.*, **49**, 331-339.

Potato plants sprayed with gibberellic acid (GA) were given extra nitrogen either through the soil (as ammonium nitrate) or through the leaves (as urea). GA increased the initial production of dry matter, but the effect did not persist even with additional N. The number of leaves on lateral branches was decreased by GA partly because leaf production on laterals at lower nodes was inhibited. N increased the rate of leaf production on lateral branches; the soil application doubled the leaf number, and the urea increased it by 50%. GA, but not N, increased the area of a main stem or lateral stem leaf; however, nitrogen produced the largest total leaf area because it produced more leaves. There was no evidence for any interaction between GA and N, either in the effect on leaf number or total leaf area. The fall in total N content per unit area caused by GA found in an earlier experiment was confirmed, and additional N did not arrest this decline. Loss of efficiency of GA-sprayed plants is unlikely to result from indirect deficiency caused by rapid leaf expansion.

- 5.3. ORCHARD, B. (1961). An automatic device for measuring leaf area. *J. exp. Bot.*, **12**, 458-464.

The design and construction of a digital device, which measures the area of leaves by scanning with a rapidly moving spot of light, is described.

- 5.4. THORNE, G. N. (1962). Survival of tillers and distribution of dry matter between ear and shoot of barley varieties. *Ann. Bot. Lond.*, **26**, 37-54.

Plants of Plumage Archer barley grown in pots produced more shoots than did Proctor, but had fewer ears at maturity, because some shoots died about 7 days before ear emergence. The number and position on the plant of the shoots that died were consistent for particular growing conditions. Shoots that died were not always the last to be produced. There were no consistent differences in dry weight, leaf area, nitrogen content or apex development between shoots that did and did not survive; nor did removing developing ears on three older shoots affect the survival of other shoots. Growth of Plumage Archer plants was not checked by death of shoots; dry matter, nitrogen and leaf area were redistributed so that increase in surviving shoots compensated for losses in the dead shoots.

The dry-weight ratio of ear to shoot was smaller for Proctor than for Plumage Archer at ear emergence and anthesis, but at maturity it was greater

for Proctor, both when ears were shaded to prevent them photosynthesising and when they were unshaded. The varietal difference in ear:shoot dry-weight ratio was reversed because the relative growth-rate of ears of Proctor was greater and because more dry matter was lost from its shoots. Both changes may have been caused by translocation to the ear of a greater proportion of the assimilate from the shoots of Proctor than of Plumage Archer. Leaves of Proctor appeared to be more efficient in producing dry matter for the ear than those of Plumage Archer.

- 5.5. THORNE, G. N. (1962). Effect of applying nitrogen to cereals in the spring or at ear emergence. *J. agric. Sci.*, **58**, 89-96.

Nitrogen applied at ear emergence to winter wheat or spring barley grown in pots with various levels of basal N fertiliser increased grain and total dry weight much less than similar amounts of N applied in March or April. No N was absorbed after ear emergence from unfertilised soil, or from the early application, and at maturity equal amounts of N had been absorbed from early and late applications.

Early N increased final ear number by increasing the number at emergence and also increased grain size. Late N had negligible effect on yield of ears present when it was applied, and caused the production of new shoots with small ears. N applied at both times increased leaf-area duration after ear emergence similarly: early N by increasing area at ear emergence and late N by delaying senescence of existing shoots and causing production of new shoots. The efficiency in grain production of the leaf area present after ear emergence was less with late than with early N, mainly because of the low efficiency of the shoots produced after ear emergence.

These results differ from those of field experiments, in which early and late N usually increase grain yield similarly, probably because in the field there were no late unproductive tillers and all the late N was utilised in increasing grain yield of existing shoots. Another difference was that N uptake from soil in the field continued until maturity.

- 5.6. WATSON, D. J. & FRENCH, S. A. W. (1962). An attempt to increase yield by controlling leaf area index. *Ann. appl. Biol.*, **50**, 1-10.

Previous work showed that the leaf area index (L) of kale crops in their later stages of growth can be much above the optimum for dry matter production, which was between 3 and 3.5. When L was held close to 3.5 during July-September 1955, by repeated thinning of plants, the total yield of dry matter, including thinnings, was increased by about 6%. When thinning was more severe yield was not increased. In a similar period in 1956 thinning that held L between 3.5 and 4 or between 3 and 3.5 did not increase total yield of dry matter, because in this year optimal L was much higher than before. The explanation of the seasonal variation in optimal L is not known.

- 5.7. WHEELER, A. W. (1961). Effect of light quality on the growth and growth-substance content of plants. *J. exp. Bot.*, **12**, 217-225.

The main effect of incandescent light on most of several species and varieties of plants grown in cabinets illuminated by fluorescent light was to increase the length of internodes. Although leaf area was little affected, incandescent light increased the dry weight of most plants.

In dwarf French bean plants the longer internodes of plants grown with additional incandescent light were associated with higher contents of gibberellic acid-like and indolyacetic acid-like growth substances.

- 5.8. WHEELER, A. W. (1962). Growth activity of the gibberellins of dwarf French bean, potato and lettuce. *J. exp. Bot.*, **13**, 36-44.

Zones with similar Rf to gibberellic acid (GA) on chromatograms of ethyl acetate extracts of dwarf French bean and potato leaves and stems and lettuce heads all promoted growth of disks of etiolated dwarf French bean leaves in darkness. The presence of a gibberellin was confirmed by tests with stems of dwarf pea, but that the substance was not GA was shown by the lack of effect in the tests with lettuce hypocotyls. The tests with dwarf maize

mutants (effects on d-3 and d-5 but not d-1) identified it as gibberellin A₅. The gibberellin content of the tissues was estimated from calibration of the growth tests with GA.

Biochemistry Department

THESIS

- 6.1. SINGH, N. (1961). Factors affecting the extractability and stability of leaf proteins.

GENERAL PAPERS

- 6.2. HOLDEN, M. (1961). Biochemical changes in Cocoa fermentation. In *The Chemistry of Cocoa*. BFMIRA Scientific and Technical Surveys No. 38, 31-40.
- 6.3. PIRIE, N. W. (1962). Prerequisites for virus classification. In "Microbial Classification", 374-393. Symposium No. 12. Society of General Microbiology.
- 6.4. PIRIE, N. W. (1962). The role of leaves in human nutrition. *King's News*, 26, 10.
- 6.5. PIRIE, N. W. (1961). Solar wind and terrestrial oxygen. *Nature, Lond.*, 190, 706.
- 6.6. PIRIE, N. W. (1961). Green leaves give edible protein. *Envoy*, 6, 8-21.
- 6.7. PIRIE, N. W. (1961). The selection and use of leafy crops as a source of protein for Man. *Proc. V int. Cong. Biochem. (Moscow)*.
- 6.8. PIRIE, N. W. (1962). The principles of classification illustrated by the problem of virus classification. *Perspectives in Biology and Medicine*. (In the press.)
- 6.9. PIRIE, N. W. (1962). Indigenous Foods. *Advanc. Sci., Lond.*, 18, 467-475.
- 6.10. PIRIE, N. W. (1961). Progress in biochemical engineering broadens our choice of crop plants. *Econ. Bot.*, 15, 302-310.
- 6.11. PIRIE, N. W. (1962). Glutathione. *Proc. roy. Soc. B*. (In the press.)

RESEARCH PAPERS

- 6.12. BYERS, M. & JENKINS, G. (1961). Effect of gibberellic acid on the extraction of protein from the leaves of spring vetches (*Vicia sativa* L.). *J. Sci. Fd Agric.*, 12, 656-661.

In connection with the production of leaf-protein in quantity, the effect of gibberellic acid on the yield of dry matter and crude protein, and on the extractability of the protein, was studied with spring vetches (*Vicia sativa* L.).

A single spraying with gibberellic acid did not significantly affect the dry matter or crude protein in the foliage at the first cut, nor did it affect the extraction.

The yields of dry matter and crude protein at the second cut were significantly lowered when the crop had been sprayed before the first cut. Two additional sprayings of gibberellic acid after the first cut further decreased these yields at the second cut. In both these cases the yields of extracted

protein at the second cut and the combined yields from the first and second cuts were significantly lower than the corresponding yields from the unsprayed plants. Spraying with gibberellic acid before the second cut only did not affect the dry matter, but lowered both the yields of crude and extracted protein, although the combined yields from the two cuts were not significantly lowered.

Hence, gibberellic acid not only fails to increase the leaf-protein extractable from spring vetches, but under certain conditions decreases it.

- 6.13. HOLDEN, M. (1962). Separation by paper chromatography of chlorophylls *a* and *b* and some of their breakdown products. *Biochim. biophys. Acta.*, **56**, 378-379.

Chlorophylls, pheophytins, chlorophyllides and pheophorbides are separated by varying the proportions of petroleum ether, benzene and acetone in the running solvent and the atmosphere of the tank.

- 6.14. MORRISON, J. E. & PIRIE, N. W. (1962). A unit for the quick freezing and drying of 8 kg. lots of moist protein. In *Freeze-Drying of Foodstuffs*, London: Borough Polytechnic. (In the press.)

A unit is described in which moist protein is distributed among four or more industrial scale glass tubes connected to a manifold; this is connected to an extended-surface heat exchanger immersed in a tank of dilute methanol at -35° . When the system is evacuated the heat exchanger is able to cope in less than a minute with the heat liberated when the mass of protein freezes. This greatly improves the texture of the product.

- 6.15. PIERPOINT, W. S. (1962). Mitochondrial preparations from the leaves of tobacco (*Nicotiana tabacum*). 4. Separation of some components by density gradient centrifugation. *Biochem. J.*, **82**, 143-147.

Preparations from tobacco leaves were centrifuged in sucrose density gradients and resolved into chloroplasts, chloroplast fragments and particles, presumably mitochondria, containing succinoxidase activity. The centrifugation sedimented fumarase as if it were attached to the mitochondria, and cytochrome oxidase as if it were associated with mitochondria and with mitochondrial fragments. No cytochrome oxidase activity was detected in chloroplasts either before or after disruption with digitonin. Glycolic oxidase did not sediment appreciably during the centrifugation, and it could not be detected in intact chloroplasts.

Plant Pathology Department

BOOK

- 7.1. GREGORY, P. H. (1961). *The Microbiology of the Atmosphere*. London: Leonard Hill.

GENERAL PAPERS

- 7.2. BAWDEN, F. C. (1961). Some effects of changing environment on the behaviour of plant viruses. In *Symposia of the Society for General Microbiology No. XI, "Microbial Reaction to Environment"*, pp. 296-311.
- 7.3. GLYNNE, MARY D. & (MOORE, F. JOAN). (1961.) *Melanospora damnosa* associated with *Fusarium culmorum* on cereals. *Plant Path.*, **10**, 168.
- 7.4. GREGORY, P. H. & BUNCE, MAUREEN E. (1961). The microflora of hay. Abstr. in *Acta allerg., Kbh.*, **16**, 74.

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- 7.5. HARRISON, B. D. (1961). Some aspects of virus multiplication in inoculated leaves. *Proc. 4th Conf. Potato Virus Diseases*. Braunschweig 1960, 50–59.
- 7.6. HIRST, J. M. (1961). The aerobiology of *Puccinia graminis* uredospores. *Trans. Brit. mycol. Soc.*, **44**, 138–140.

RESEARCH PAPERS

- 7.7. BAWDEN, F. C. (1961). The susceptibility of *Rhoeo discolor* to infection by tobacco mosaic virus. *J. biol. Chem.*, **236**, 2760–2761.

Rhoeo discolor was reported in the U.S.A. to be insusceptible to infection by whole tobacco mosaic virus, but susceptible when inoculated with the virus nucleic acid, implying: (a) that infection necessarily entails the nucleic acid separating from the protein of the virus, and that (b) some plants may resist infection because they do not contain systems able to disrupt the virus particles. However, *R. discolor* was found to be susceptible, but a poor host in which virus multiplication becomes readily demonstrable only when inoculated leaves are brightly illuminated. Multiplication is easier to establish unequivocally with inocula of nucleic acid than of intact virus, because results are not complicated by residual infectivity from the inoculum.

- 7.8. BAWDEN, F. C. & SINHA, R. C. (1961). Effects of ultraviolet radiation on infection by intact and phenol-disrupted red clover mottle virus. *Virology*, **14**, 198–206.

Exposing French bean leaves to ultra-violet radiation after inoculation with red clover mottle virus decreased numbers of infections more than did exposure before inoculation. The decrease produced by a given dose of radiation differed with plants in different physiological states. Treatments that increased susceptibility to infection also increased the effects of the radiation. Irradiation before inoculation affected lesion numbers similarly whether the inoculum was intact or phenol-disrupted virus, provided the leaves were in the dark after irradiation, but when leaves were in the light effects were much greater with disrupted virus. Intact virus is apparently better able than disrupted virus to survive, while light restores the capacity of leaves to support infection. The effects of photoreactivation depended on the radiation dose; leaves given small doses before inoculation and then exposed to visible light produced more lesions than the controls when the inoculum was intact virus, but usually fewer when it was disrupted virus. Irradiation immediately after inoculation decreased lesions more with disrupted virus than with intact virus, but infection centres initiated by disrupted virus increased their resistance sooner and more rapidly. Infection centres initiated by intact virus retained their original susceptibility for about 2 hours at 24°–28° and 6–8 hours at 16°. At 32° resistance did not increase even after 22 hours; plants placed at 24° after 22 hours at 32° produced about half as many lesions as those kept at 24° continuously after inoculation. At 32°, infection centres initiated by disrupted virus also failed to increase their resistance to inactivation by the radiation, and few survived 4 hours, even in unirradiated leaves. Hence, whatever may happen at lower temperatures, intact virus seems not to dissociate into protein and nucleic acid in leaves at 32°.

- 7.9. (BROADBENT, L.) & HEATHCOTE, G. D. (1961). Winged aphids trapped in potato fields, 1942–1959. *Ent. exp. & appl.*, **4**, 226–237.

Sticky aphid-traps were operated over potato crops at Rothamsted during 18 years, and elsewhere for shorter periods, to get information about the activity of *Myzus persicae* in relation to the spread of virus diseases. Numbers of total aphids, *M. persicae*, *Aphis fabae* and *Brevicoryne brassicae*, caught per week are given. Annual rhythms in aphid numbers were unpredictable, although there was a tendency for *A. fabae* to be few during the year after one in which they had been numerous. *M. persicae* were few in summer when they and their predators or parasites had been numerous in spring, and were often

numerous in summer when they had been few in spring. *A. fabae* were more numerous during most years than *M. persicae*, and *B. brassicae* usually scarce. Severe winters affected *M. persicae* more than the other two species.

- 7.10. BUNCE, MAUREEN E. (1961). *Humicola stellatus* sp. nov., a thermophilic mould from hay. *Trans. Brit. mycol. Soc.*, **44**, 372-376.

Humicola stellatus sp. nov., a thermophilic mould found in mouldy hay from England and Wales, is described. *Monotospora lanuginosa* (Griff & Maubl.) Mason is transferred to *Humicola*.

- 7.11. BUXTON, E. W. (CULBRETH, W.) & (ESPOSITO, R. G.) (1961). Separation of forms and physiologic races of pathogenic *Fusarium oxysporum*. Abstr. in *Phytopathology*, **51**, 575.

Two physiologic races of *Fusarium oxysporum* f. *cubense*, two of *F. oxysporum* f. *pisi* and one of *F. oxysporum* f. *lycopersici*, all of which appear identical in culture, were distinguished from each other by serological techniques. Gel-diffusion techniques gave more reliable results than agglutination. Haemagglutination, using the reactions between red cells of human blood group O and extracts of conidia of the fungi, also enabled distinctions to be made.

- 7.12. GIBBS, A. J. & (TINSLEY, T. W.) (1961). Lucerne mosaic virus in Great Britain. *Plant Pathology*, **10**, 61-62.

Lucerne mosaic virus was found to be common in British crops of lucerne, and red and white clover. Most isolates of the virus from commercial lucerne crops gave only necrotic lesions on French bean plants, but 1.7% of the isolates infected this plant systemically. The symptoms caused by one "necrotic" isolate in test plants are described.

- 7.13. GREGORY, P. H. (LONGHURST, T. J.) & (SREERAMULU, T.) (1961). Dispersion and deposition of airborne *Lycopodium* and *Ganoderma* spores. *Ann. appl. Biol.*, **49**, 645-658.

Spores were liberated at 0.25 and 1.0 m. above grass. Airborne concentrations at twenty or more points in the spore cloud were measured with specially designed and calibrated miniature suction traps, operated off a portable vacuum system. Deposition in the downwind direction was measured on artificial surfaces on the ground. Measurements were made up to 10 m. from the source.

The observed increase in horizontal cross-wind standard deviation of the *Lycopodium* cloud agreed well with O. G. Sutton's theory, but was incompatible with that of W. Schmidt.

The coefficient of deposition, p , calculated from mean cloud concentration per c.c. and deposition to ground per cm.², as well as the velocity of deposition, v_g , varied with distance from source. Both p and v_g were larger for *Lycopodium* than for *Ganoderma*, and at the greater distances tested, v_g approximated to the expected terminal velocities of the particles in still air.

The total number (Q_0) of *Lycopodium* spores liberated in each experiment was known, and tentative estimates of the proportion deposited within the sampling area indicated that, under day-time winter conditions in England, the cloud lost not less than 13-24% of its load within 10 m. of the source.

- 7.14. HARRISON, B. D. (1961). Identity of red currant spoon leaf virus. *Tijdschr. PlZiekt.*, **67**, 562-565.

Red currant spoon leaf virus, isolated from red currant in the Netherlands, is a strain of raspberry ringspot virus; it shares most of its antigenic groups with the "type" strain from Scottish raspberry, but causes distinctive symptoms in *Petunia hybrida*. It differs from tomato ringspot virus, obtained by Hildebrand (1942) from red currant in the U.S.A. Klesser's (1951) red currant ringspot virus is probably the same as red currant spoon-leaf virus.

- 7.15. HARRISON, B. D., (MOWAT, W. P.) & (TAYLOR, C. E.) (1961). Transmission of a strain of tomato black ring virus by *Longidorus elongatus* (Nematoda). *Virology*, **14**, 480-485.

Longidorus elongatus (de Man) was always found in soil from patches in raspberry and strawberry plantations where the plants were infected with the beet ringspot (Scottish) strain of tomato black ring virus but rarely elsewhere in the same plantations. *L. elongatus* hand-picked from virus-containing field soil transmitted the virus to sugar beet, turnip and spinach seedlings, but did so less often than might have been expected from the infectivity of the whole soil from which the nematodes came. Non-infective *L. elongatus* acquired and subsequently transmitted the virus from infected cucumber and potato plants. When hand-picked adult and larval *L. elongatus* were used separately, only larvae transmitted. Also, when infective soil was fractionated by sieving through meshes of successively smaller size, the infectivity of the fraction retained on each sieve, relative to the number of *L. elongatus* it contained, was greatest for samples containing the smallest larvae. A previously undescribed species of *Longidorus*, closely related to *L. elongatus*, was associated with an outbreak of the lettuce ringspot (English) strain of tomato black ring virus.

- 7.16. HARRISON, B. D. & WINSLOW, R. D. (1961). Laboratory and field studies on the relation of arabis mosaic virus to its nematode vector *Xiphinema diversicaudatum* (Micoletzky). *Ann. appl. Biol.*, **49**, 621-633.

Xiphinema diversicaudatum is widely distributed in southern Britain, mainly in heavy soils, but also in the peat soil of the Fens and in medium-textured soils in the south-west. Patches of plants infected with arabis mosaic virus (AMV) in a range of crops including some, like celery and marrow, not before known to be hosts, coincide with patches of soil infested with *X. diversicaudatum*. Roots of some plants infested with the nematode carried small galls; not all such plants were infected with, or even susceptible to, AMV. Adult *X. diversicaudatum* transmitted AMV more readily than larvae, but none of 103 nematodes, transferred when moulting, infected healthy plants. *X. diversicaudatum* were still infective after 24 days in moist peat free from plants.

X. diversicaudatum is common in several districts in soil from old hedgerows, but not in the adjacent fields. Hedgerow trees seem to be hosts of the nematode, and at least one, elder, is also a host of AMV. In other districts plants with AMV occur in crops near to infested hedges or isolated trees, and on land taken into cultivation after being derelict. In the Tamar Valley, Devon, *X. diversicaudatum* is common in pastures; white clover in these often contains AMV. Planting such fields with strawberry leads to disease outbreaks.

A few *X. diversicaudatum* occur down to 3 feet in soil, but most are at 3-9 inches. At a site where arable land has reverted to woodland the nematodes have apparently spread from a hedge into the woodland at an average rate of 1 foot/year over a period of 75 years. It is suggested that both *X. diversicaudatum* and AMV are common constituents of natural woodland in Britain and that their incidence has decreased since the advent of agriculture.

- 7.17. HASTIE, A. C. (1962). Genetic recombination in the hop-wilt fungus *Verticillium albo-atrum*. *J. gen. Microbiol.*, **27**, 373-382.

Heterokaryons obtained between nutritional mutants of the imperfect fungus *Verticillium albo-atrum* were very unstable, and heterokaryotic hyphal tips growing out from mixed inocula were difficult to find. Heterokaryotic conidia were not detected, in spite of the fact that about 1% of the spores contained two or three nuclei. Heterozygous nuclei in uninucleate conidia from mixed cultures yielded recombinant phenotypes at a higher frequency than usually observed in the other imperfect fungi that have been studied genetically. With no easily applicable criterion of chromosome number, such as spore size, the interpretation of results is difficult, but the genetic recombination demonstrated here seems likely to be accomplished through a parasexual system. Nuclei heterozygous at some loci but homozygous at others were formed from nuclei heterozygous at four marked loci, and were detected by isolating second-

order segregants. These heterozygous segregants were presumably produced by mitotic recombination.

- 7.18. (COCKBAIN, A. J.) & HASTIE, A. C. (1961). Susceptibility of the bed bug, *Cimex lectularius* Linnaeus, to *Aspergillus flavus* Link. *J. Insect Path.*, **3**, 95-97.

(For summary see below No. 10.16.)

- 7.19. HEATHCOTE, G. D. & (BROADBENT, L.) (1961). Local spread of potato leaf roll and Y viruses. *Eur. Potato J.*, **4**, 138-143.

In 1957 and 1959 potato tubers infected with either leaf roll or potato Y viruses at planting time were planted in pots which were sunk into the ridges of a crop of healthy potatoes for part of the season only. In 1957 both viruses spread to many neighbouring plants from "infectors" exposed during June, but not from those exposed later. In 1959 all spread again occurred before mid-July. There was no more spread from young "infectors" later in the season than from those of the same age as the crop, and the disease incidence in these plots did not differ significantly from those without "infectors". There was negligible spread of virus from plants infected early in the same season.

Aphids were few during late summer in both years, but the experiments confirmed that most spread within the crop occurs early at Rothamsted, and that insecticidal treatments aimed at decreasing virus spread should begin early; continuing them after mid-July is often less important.

- 7.20. HIRST, J. M., (LE RICHE, H. H. & BASCOMB, C. L.). (1961). Copper accumulation in the soils of apple orchards near Wisbech. *Plant Path.*, **10**, 105-108.

During epidemiological studies of apple scab, *Venturia inaequalis* (Cooke) Wint., in the Wisbech area of Cambridgeshire, soils of some orchards on one holding were found to be atypical and unusually rich in copper. This paper compares the soils of two atypical orchards (AB and AR) with typical soils from five grassed and two arable orchards on other holdings, all within 5 miles of Wisbech. Orchard AR had been used for an experiment to test what effect different amounts of the sodium salt of dinitro-ortho-cresol had on the number of ascospores liberated from leaves which had overwintered on the ground. The soil of these plots was later sampled to find whether the treatments had affected the earthworm population, but the results were inconclusive, as very few worms were found in treated or untreated plots. During sampling, J. W. Stephenson noticed that the soil profile was atypical of grass-covered apple orchards in the area, and further work suggested that plant-protective chemicals, particularly Bordeaux mixture, may have modified the soil.

- 7.21. HIRST, J. M. & STEDMAN, O. J. (1961). The epidemiology of *Phytophthora infestans*. III. Spraying trials 1952-1958. *Plant Path.*, **11**, 7-13.

The yield of Majestic potatoes was increased significantly in only 2 of 7 years by applying two copper oxychloride sprays, whether or not the haulms were killed by sulphuric acid. Rows along which tractors passed while spraying yielded on average 0.7 tons/acre less than undamaged rows. Up to 20% of King Edward tubers were infected in 1957, but at no time were more than 2.5% of Majestic tubers blighted.

- 7.22. HIRST, J. M. & STEDMAN, O. J. (1961). The epidemiology of apple scab (*Venturia inaequalis* (Cke.) Wint.). I. Frequency of airborne spores in orchards. *Ann. appl. Biol.*, **49**, 290-305.

The number of ascospores caught by automatic volumetric spore traps differed widely in six orchards where the air was sampled in some or all of the years 1955-59. To compare amounts of inoculum in different orchards the total catch in each was expressed as the "relative ascospore dose". The reason for the much smaller doses in the later years is uncertain. The results confirmed earlier work on the phenology of ascospore liberation and stressed the practical need to decrease their number as much as possible.

Because conidia have previously been trapped almost only on wet and windy days, they have been considered to be rarely air-dispersed. Our apparatus, which efficiently traps dry conidia but catches water-borne ones only when in very small droplets, caught airborne conidia in all orchards where they operated during summer. Traps among heavily infected, unsprayed trees caught most conidia around noon on warm dry days, and the highest concentration measured exceeded 1,300/m.³ of air.

- 7.23. KASSANIS, B. (1961). The transmission of potato aucuba mosaic virus by aphids from plants also infected by potato viruses A or Y. *Virology*, **13**, 93-97.

None of twelve strains of potato aucuba mosaic virus (PAMV) tested was transmitted by the aphid *Myzus persicae* Sulz. from plants infected with PAMV alone. Strains differed in the ease with which they were transmitted from plants which were also infected with either potato virus A or Y. Some were only occasionally transmitted, and others readily—some more readily from plants infected with Y than with A, and others only from plants infected with Y.

Infection with either virus Y or A increased the concentration of PAMV, more so by Y than by A. The transmissibility of PAMV was not correlated with its concentration in expressed sap. The concentration of PAMV differed at different seasons, and in summer was too low to be detected serologically in plants also infected with virus A.

- 7.24. KASSANIS, B. (1961). Potato paracrinkle virus. *Eur. Potato J.*, **4**, 13-24.

Potato paracrinkle virus and potato virus S share only a few antigenic groups and do not protect plants against one another. All plants from commercial stocks of the variety King Edward tested were virus-infected, some by potato paracrinkle virus alone, some by both viruses and one by potato virus S only.

Infected King Edward plants are not symptomless, as they were long thought to be; in comparison with plants of a virus-free clone, derived from an apical meristem, they are less vigorous, and their leaves are paler and more ruffled. The use of virus-free Arran Victory plants derived from apical meristems showed that severe paracrinkle symptoms can be caused by potato paracrinkle virus without potato virus S being present. Potato paracrinkle virus occurs in stocks of King Edward in strains of different virulence towards Arran Victory. Some of these strains are transmitted by *Myzus persicae*.

The name leaf-rolling mosaic is proposed for a group of serologically related viruses, divided into three sero-types.

- 7.25. KASSANIS, B. & NIXON, H. L. (1961). Activation of one tobacco necrosis virus by another. *J. gen. Microbiol.*, **25**, 459-471.

Preparations of the Rothamsted culture of tobacco necrosis virus always gave two and usually three zones when centrifuged in sucrose density gradients. The top zone consisted of polyhedral particles with a sedimentation constant of 50S, the middle zone of larger polyhedral particles with 116S and the bottom zone, when present, consisted of the 50S particles aggregated in groups of 12. Neither the small particles (50S) nor their aggregates were infective when inoculated either to tobacco or French bean plants, but they became so when inoculated together with the large particles (116S). The small and large particles are serologically unrelated, and seem to be different viruses, one of which depends on the other for some process that allows it to multiply to detectable amounts.

The Rothamsted culture produces local lesions of different sizes in French bean. Virus isolated from single large lesions and passed through a succession of single lesions gave, when bulked in tobacco, preparations containing up to 500 large to 1 small particle. Evidence is given which suggests that the few small particles were acquired as contaminants when the virus was bulked in tobacco, and it seems probable that small particles would not be produced in leaves infected only with the large particles. Virus obtained from small lesions when bulked gave preparations containing particles of both sizes, with ratios of large to small particles up to 1 : 10. Inocula of large particles produced only

large lesions, whereas mixed inocula produced large and small lesions, in proportions which depended on the ratio of the two kinds of particles in the inoculum. Two different tobacco necrosis viruses activated the small particles, but tobacco mosaic and some other viruses did not.

Particles of the two activating viruses differed in size and in their stability when negatively stained in phosphotungstate. When fixed and negatively stained they appeared to be angular, but much less so than when shadowed. Small particles tended to pack in regular arrays, and one type of packing suggested that they have a fivefold axis of symmetry.

- 7.26. KLECZKOWSKI, A. (1961). Serological behaviour of tobacco mosaic virus and of its protein fragments. *Immunology*, **4**, 130-141.

The protein obtained when tobacco mosaic virus is disrupted with alkali is antigenically heterogeneous, whereas the intact virus is homogeneous. Aggregating the protein by acidification makes it again antigenically homogeneous. In comparable conditions, antibody/antigen ratio is considerably higher in precipitates formed by the protein than in those formed by the virus. Aggregating the protein restores the ratio to that given by the original virus.

Electron-microscopic examination shows that in extreme antibody excess each virus particle is covered with a layer of antibody molecules. In these conditions, therefore, individual antibody molecules seem not to bridge directly between different virus particles, but they may do so in the zone of equivalence.

- 7.27. KLECZKOWSKI, A. & (KAMMEN, A. VAN). (1961.) Protection from proteolysis by aggregating the protein isolated from tobacco mosaic virus. *Biochim. biophys. Acta*, **53**, 181-185.

Disaggregated protein isolated from tobacco mosaic virus is hydrolysed by chymotrypsin and papain, but when aggregated into rod-shaped particles the protein, like the original virus, resists attack by the enzymes. This suggests that only some walls of the protein sub-unit are susceptible to proteolysis, and these walls become inaccessible to the enzymes when the protein aggregates in the orderly fashion required to form rods.

- 7.28. LAPWOOD, D. H. (1961). Potato haulm resistance to *Phytophthora infestans*. I. Field assessment of resistance. *Ann. appl. Biol.*, **49**, 140-151.

The resistance to potato blight (*Phytophthora infestans* (Mont.) de Bary) of the haulms of four potato varieties, Up-to-Date (UD), King Edward (KE), Majestic (MJ) and Arran Viking (AV), was assessed in the field from 1956 to 1959. Although these varieties are reputed to differ appreciably in resistance, the differences measured were smaller than expected and significant in only two seasons. They were shown better by measurements on individual leaves than by assessing effects on whole plots. The greater resistance of AV and MJ, compared with UD and KE, was correlated with a slower increase of blight at the start of an attack rather than with differences in the rate of haulm destruction when the attack was well advanced. However, there was some evidence that leaves of KE died most rapidly and leaves of AV most slowly after infection.

- 7.29. LAPWOOD, D. H. (1961). Potato haulm resistance to *Phytophthora infestans*. II. Lesion production and sporulation. *Ann. appl. Biol.*, **49**, 316-330.

The slower increase of blight (*Phytophthora infestans* (Mont.) de Bary) in field plots of Majestic (MJ) and Arran Viking (AV) than of Up-to-Date (UD) and King Edward (KE) potatoes seems more closely related to the production of fewer spores than to greater resistance of leaves to infection.

Sporing was decreased, not by differences in generation time, but because fewer spores were produced per lesion on MJ and AV, especially when lesions were small (young). Infected cells of AV died more rapidly than cells of UD and KE, and so left a smaller area of sporing tissue in young lesions. Although the fungus advanced at much the same rate in leaves of the four varieties, sporing annuli were narrower on older (larger) lesions on AV unless high relative

humidity persisted continuously. Sporangioophores and sporangia were formed more rapidly on UD than AV when non-sporing lesions were transferred to high humidity. The ecoclimate of a crop of UD did not increase the sporulation of infected leaves of AV exposed within it, but sporulation was slightly decreased when infected UD leaves were exposed in a crop of AV. Generally KE behaved like UD, with MJ intermediate between these and AV.

The lower leaf-surface was more susceptible to infection than the upper. Differences in susceptibility of lamina between varieties were inconsistent. MJ and AV were more resistant than UD and KE when inoculated in leaf axils.

- 7.30. LAPWOOD, D. H. (1961). Potato haulm resistance to *Phytophthora infestans*. III. Lesion distribution and leaf destruction. *Ann. appl. Biol.*, **49**, 704-716.

Reasons were sought for the difference in haulm resistance to potato blight (*Phytophthora infestans* (Mont.) de Bary) of four potato varieties. Up-to-Date produced more foliage than King Edward, Majestic and Arran Viking, and its denser canopy prolonged periods of high relative humidities and lowered midday temperatures by a few degrees. When field conditions favoured infection the fungus spread in all varieties, but most extensively in King Edward and least in Arran Viking. Infections developed first, mainly in the lower canopy, then the middle and finally in the upper canopy, with lesions on leaves and leaflets distributed similarly on all varieties.

The fungus advanced at the same rate in leaf laminae of all the varieties, but not in petioles, which were girdled more rapidly in Up-to-Date and King Edward than in the other two, and consequently led to the collapse of more leaves.

Majestic and Arran Viking are more resistant than Up-to-Date and King Edward in the field, because their leaves are infected more slowly early in the blight attack and die more slowly after infection.

- 7.31. LAPWOOD, D. H. (1961). Laboratory assessments of the susceptibility of potato haulm to blight (*Phytophthora infestans*). *Eur. Potato J.*, **4**, 117-128.

The reactions to *Phytophthora infestans* of the haulm of forty-three potato varieties of different maturity were compared with that of the variety Majestic. Laboratory tests assessed relative resistance by five criteria: (1) ease of infection of leaf lamina; (2) susceptibility of leaf tissue to fungal advance; (3) spores produced per area of infected leaf; (4) susceptibility of stem; and (5) susceptibility of leaf petiole when leaf axils were inoculated. Susceptibility of resistance for each criterion was based on a significant difference ($P = 0.05$) between the test variety mean and Majestic. Early varieties were more susceptible than Majestic, most by all criteria; different maincrop varieties reacted differently, and resistance usually showed as a decrease in number of spores produced; most late-maturing varieties were more resistant than Majestic, the fungus advanced more slowly and produced fewer spores.

- 7.32. LAPWOOD, D. H. (1961). Sporulation of blight on potato tubers within ridges. *Plant Path.*, **10**, 40.

Potato blight was found sporulating from the lenticels and sometimes eyes of infected tubers, underground, within the ridges, first on Ulster Ensign and later on Up-to-Date, King Edward and Arran Banner. Sporing tubers were readily found when the ridge was drying after rain, but were difficult to find during or immediately after further rain.

- 7.33. LAPWOOD, D. H. (with MCKEE, R. K.) (1961). Reaction of tubers of R-gene potato clones to inoculation with specialised races of *Phytophthora infestans*. *Eur. Potato J.*, **4**, 3-13.

Tubers of 46 R-gene potato clones were inoculated with races of *Phytophthora infestans*, which either: (1) caused a hypersensitive reaction on the leaves of the clone, or (2) could infect and spread in the leaves. The gene R_1 conferred comparable hypersensitivity to tubers and leaves, whereas genes R_2 , R_3 and R_4 often did not. Races giving a hypersensitive reaction in the leaves of R_2 , R_3 and R_4 clones grew in the tubers, but more slowly than in clones without these genes.

Tubers of most clones were highly susceptible (often more so than the clone King Edward) to races of the fungus that spread in their leaves. Orion and Reaal were two of the few clones whose tubers resisted infection by races able to invade their leaves.

- 7.34. MICZYNSKI, K. A. (1960). An attempt to inhibit the multiplication of tobacco mosaic virus in tissue culture by its antiserum. *Ann. appl. Biol.*, **48**, 739-741.

Extracts from tobacco tissue cultures infected with tobacco mosaic virus grown in medium containing antiserum to the virus had only one-half to one-sixteenth as much virus as extracts from tissues grown in medium without the antiserum. When tissues grown with antiserum were thoroughly washed before they were extracted their extracts contained as much virus as extracts of tissues grown without antiserum. The antiserum did not affect virus multiplication, but antibodies in the tissues may have precipitated virus either in the cells or when the tissues were macerated.

- 7.35. (WEIR, A. H.,) NIXON, H. L. & WOODS, R. D. (1962). The measurement of dispersed clay flakes with the electron microscope. In *Clays and Clay Minerals*. London: Pergamon Press pp. 419-423.

(For summary see No. 3.5. above.)

Nematology Department

BOOK

- 8.1. SHEPHERD, A. M. (1962). *The Emergence of Larvae from Cysts in the Genus Heterodera*. Farnham Royal: Commonwealth Agricultural Bureaux, 87 pp.

GENERAL PAPERS

- 8.2. DONCASTER, C. C. (1962). Natürliche wirtschaftlich wichtiger Schadnematoden. *Umschau*, **62**.
- 8.3. GOODEY, J. B. (1962). Taxonomic relatedness in Nematology. *Ann. appl. Biol.*, **50**, 175-177.
- 8.4. JONES, F. G. W. (1962). The nematode problem. In: *Proceedings of the British Insecticides and Fungicides Conference*, Brighton, 1961.
- 8.5. PEACHEY, J. E. (1962). Investigations on nematicidal activity of and crop responses to chemical soil sterilants. In *Proceedings of the British Insecticides and Fungicides Conference*, Brighton, 1961.
- 8.6. SHEPHERD, A. M. (1961). Nematode-trapping fungi in Danish agricultural soils. *Horticultura*, **15**, 94-96.

RESEARCH PAPERS

- 8.7.* BLAKE, C. D. (1961). Root rot of bananas caused by *Radopholus similis* (Cobb) and its control. *Nematologica*, **6**, 295-310.

Radopholus similis causes a serious root-rot of bananas (*Musa cavendishii*) in New South Wales. The histopathology of root lesions and the role of the fungi *Fusarium oxysporum* and *Rhizoctonia solani* as secondary colonists are described. Reproduction on *M. acuminata banksii* and *Saccharum officinarum*, but not on *Citrus* spp. showed the "banana" race of *R. similis* was responsible. Root rot was controlled for 6 months by preplant soil fumigation with the

* Work done in New South Wales.

nematicides methyl bromide, "D.D.", "Vapam" or "Nemagon", but reinfestation occurred after 11 months. *R. similis* was not found in virgin soils, but was introduced by planting infested sets. Sets less than 13 cm. diameter were disinfested by immersion in water at 55° for 20 minutes without abnormal set losses. Chemical dipping failed to disinfest them. A hot-water bath and a method for the bulk treatment of sets are described.

- 8.8. BLAKE, C. D. (1961). Importance of osmotic potential as a component of the total potential of the soil water on the movement of nematodes. *Nature, Lond.*, **192**, 144-145.

Larvae of *Ditylenchus dipsaci* moved at similar speeds through sands of particle size 250-500 μ wetted with distilled water or urea solution. Movement in both moisture regimes was related to the moisture characteristic and was fastest when the pores of the sand were draining. Movement in sand depends on the forces holding the soil water in the pore spaces and is independent of the osmotic pressure of the soil water, until the solute concentration is high enough to cause incipient plasmolysis of the nematodes. The length of larvae suspended in urea solutions decreased as the osmotic pressure of the solutions increased. Shrinking was greatest in the range 0.001-1M concentration and the larvae reached their minimum lengths at approximately pF = 4.1. The solute concentration required to kill nematodes is about the same as that which causes permanent wilting of plants, and so it is unlikely that soil additives such as sugars which act only osmotically would be useful nematicides.

- 8.9. CLARK, W. C. (1962). *Amphorostoma saccatum* n. gen. et sp. Family Leptonchidae (Enoplida, Nematoda). *Nematologica*, **7**, 193-196.

A new genus *Amphorostoma* is proposed within the family Leptonchidae for nematodes with a flask-shaped, sclerotised stomatal lining, and large amphids with sinuous apertures. In the only known species the female has a single, outstretched, anterior ovary, with a large post-vulval sac. The type, and only species, *Amphorostoma saccatum* n. sp. is described.

- 8.10. CLARK, W. C. (1962). Evolution within the family Mononchidae (Enoplida, Nematoda). *Nematologica*, **7**, 251-255.

The course of evolution within the family Mononchidae is deduced from morphology and ontogeny as far as this is known. Early in evolution the Mononchidae divided into two groups, one with a tuberculate oesophago-intestinal junction and a broad base to the sclerotised stoma and the other non-tuberculate and with a narrow stoma base. Further evolution within both lines was smaller size and eventual loss of the subventral teeth. In the non-tuberculate group subventral denticles appeared on the stoma walls, but in most genera these have become less and tended to fuse to form subventral ridges (e.g. *Prionchulus*), which in most *Mononchus* spp. have been lost entirely.

- 8.11. CLARK, W. C. (1962). The systematic position of the Alaimidae and the Diphtherophoroidea (Enoplida, Nematoda). *Nematologica*, **7**.

An earlier classification of the order Enoplida is amended by transferring the Diphtherophoroidea from the sub-order Dorylaimina to the sub-order Alaimina. The change is based primarily on the occurrence of: (1) well-developed excretory pores, and (2) males with one testis and non-muscular, non-differentiated vasa deferentia, both features characteristic of the Alaimidae and the Diphtherophoroidea but not of the Dorylaimina, to which the Diphtherophoroidea were previously referred.

- 8.12. DONCASTER, C. C. & HOOPER, J. D. (1961). Nematodes attacked by Protozoa and Tardigrades. *Nematologica*, **6**, 333-335.

Nematodes in a water extract from turf were ingested by a protozoon, *Urostyla* sp. The nematodes eventually escaped from ingestion without apparently being harmed, but sometimes the *Urostyla* were damaged. Tardigrades, *Macrobotus* sp., readily attacked and fed on nematodes in a water extract from soil, eventually killing them.

- 8.13. (HARRISON, B. D.) & WINSLOW, R. D. (1961). Laboratory and field studies on the relation of arabis mosaic virus to its nematode vector *Xiphinema diversicaudatum* (Micoletzky). *Ann. appl. Biol.*, **49**, 621-633.

(For summary see above No. 7.16.)

- 8.14. HESLING, J. J., PAWELSKA, K. & SHEPHERD, A. M. (1960). The response of potato root eelworm *Heterodera rostochiensis* Wollenweber and beet eelworm *H. schachtii* Schmidt to root diffusates of some grasses, cereals and of *Tagetes minuta*. *Nematologica*, **6**, 207-213.

Three experiments failed to produce evidence that root diffusates from cereals and grasses stimulate eggs of *Heterodera rostochiensis* to hatch *in vitro*. Diffusate from *Tagetes minuta*, tested in one experiment, neither stimulated nor inhibited hatch. Diffusate from cereals, grasses and *Tagetes minuta* differed very little in effect from soil water. Diffusate from rye and perennial ryegrass did not stimulate cysts of *H. schachtii*. The experiment emphasised the need to test diffusates over a range of dilutions.

- 8.15. HOOPER, D. J. (1961). A redescription of *Longidorus elongatus* (de Man, 1876) Thorne & Swanger, 1936. (Nematoda, Dorylaimidae) and descriptions of five new species of *Longidorus* from Great Britain. *Nematologica*, **6**, 237-257.

Longidorus elongatus (De Man, 1876) Thorne & Swanger, 1936, is redescribed from specimens obtained from the type locality. *L. elongatus* is characterised by its attenuated body, continuous to slightly expanded lip region flattened anteriorly, dorsally convex, roundly conoid tail as long or slightly longer than the anal-body-width, and stylet 85-95 μ long. Measurements and descriptions are also given of specimens, including males and larvae, from Britain. *L. leptcephalus* n. sp. and *L. attenatus* n. sp. differ from *L. elongatus* in that the former is smaller with a narrower lip region, shorter stylet and more pointed tail; the latter has a more attenuated body, greatly expanded lip region, more pointedly conoid tail and a shorter stylet. *L. goodeyi* n. sp. and *L. caespiticola* n. sp. are slightly longer and appear more robust than *L. elongatus*. *L. goodeyi* has large, asymmetrically bilobed amphids and a roundly flattened lip region; *L. caespiticola* has a roundly conoid lip region and large pouch-shaped amphids. Both of these species have blunt conoid to round tails about an anal-body-width long. *L. macrosoma* n. sp. is recognised by its size, 8-10 mm., continuous truncate lip region and short tail. Measurements of larval stages and illustrations of their tails are given for each species.

- 8.16. HOOPER, D. J. (1961). A method for attaching the funnel to the flask for use in the Seinhorst two-Erlenmeyer-flask soil extraction technique. *Nematologica*, **6**, 336.

Flasks for use in the two-Erlenmeyer extraction technique have a rubber collar of cycle inner tube fitted around the neck so as to leave a small inwardly projecting overlap. Three rubber bands are held in place by a ring of copper wire round the flask neck. A plastic funnel, cut down to fit just inside the flask rim, is also fitted with an overlapping rubber ring. The funnel is held in place on the flask by stretching the rubber bands on the wire around the flask neck over screw heads fixed in a collar round the stem of the funnel.

- 8.17. HOOPER, D. J. (1961). Effects of a nematode on the growth of mushroom mycelium. *Nature, Lond.*, **193**, 496-497.

Aphelenchus avenae from mushroom compost fed on mushroom hyphae on agar plates and reproduced rapidly. When added to tubes of compost with growing mushroom mycelium, *A. avenae* also reproduced rapidly and the mycelium was destroyed.

- 8.18. HOOPER, D. J. (1962). Observations on *Aphelenchoides limberi* Steiner, 1936 from mushroom compost. *Nematologica*, **7**, 216-218.

Aphelenchoides limberi Steiner 1936 from mushroom compost readily feeds on mushroom hyphae on agar plates, reproduces rapidly and breaks down the

mycelium. It also reproduces on the fungus *Botrytis cinerea*. Appearance and measurements of the specimens from mushroom closely agree with Steiner's original description. The shape of the tail terminus is very variable. No males occurred in the cultures.

- 8.19. JONES, F. G. W. (1961). The potato-root eelworm, *Heterodera rostochiensis* Woll. in India. *Curr. Sci.*, **30**, 187.

Potato-root eelworm is reported in India for the first time at Ootacamund in the Nilgiris about 7,000 feet above sea-level.

- 8.20. KRUSBERG, L. R. (1961). Studies in the culturing and parasitism of plant-parasitic nematodes, in particular *Ditylenchus dipsaci* and *Aphelenchoides ritzemabosi* on alfalfa tissues. *Nematologica*, **6**, 181-200.

Ditylenchus dipsaci and *Aphelenchoides ritzemabosi* reproduced rapidly on alfalfa callus tissue grown on a nutrient agar medium containing 2 : 4-dichlorophenoxyacetic acid (2 : 4-D). Cultures inoculated with fifty nematodes and kept at 22° contained 40,000-80,000 individuals after 2 months. *Pratylenchus zae* and *P. penetrans* reproduced well and *Tylenchorhynchus capitatus* and *Hoplolaimus coronatus* slowly on callus. Four of these species were maintained alive in such cultures for 2 years without subcultures.

The histopathology of *D. dipsaci* and *A. ritzemabosi* on alfalfa seedlings grown in soil, seedlings grown aseptically on nutrient agar medium and callus tissue grown aseptically on nutrient agar medium plus 2 : 4-D was examined. *D. dipsaci* penetrated directly through the epidermis in the bases of cotyledons of alfalfa seedlings in soil and formed cavities in cortical parenchyma within 12 hours of inoculation. Infected stems were noticeably swollen at 36 hours after inoculation. Many parenchyma cells were destroyed and others distorted in galled tissue, particularly in young, actively growing shoots. Only cavities were formed in roots of infected seedlings growing on agar medium with no galling; shoot galls were identical with those of infected plants in soil. *A. ritzemabosi* fed primarily as an ectoparasite on shoots of alfalfa seedlings, inhibiting apical growth and resulting in severely stunted and malformed plants, but a few lived in the mesophyll of cotyledons. Both nematode species fed and reproduced in the loose parenchyma of callus tissue, with the nematodes moving from the callus to the agar and test-tube walls in older cultures.

Sugars, organic acids and amino acids were examined in alfalfa tissues as used in the histological studies. Neither nematodes nor the conditions under which plants or tissues were grown affected qualitatively the sugars or organic acids, and affected only two of the twenty-three major amino acids identified. Gall tissue of plants infected *D. dipsaci*, and all callus tissue samples contained free tryptophane, whereas healthy plants or those parasitised by *A. ritzemabosi* did not. Tissue parasitised by *A. ritzemabosi* contained abundant free tyrosine, whereas nematode-free or *D. dipsaci*-infected tissues contained little or none.

- 8.21. (LUC, M.) & GOODEY, J. B. (1962). *Hirschmannia* n.g. differentiated from *Radopholus* Thorne, 1949 (Nematoda: Tylenchoidea). *Nematologica*, **7**, 197-202.

Re-examination of a specimen of *Tylenchorhynchus spinicaudatus* Sch. Stek., 1944 showed it to be conspecific with *Radopholus lavabri* Luc, 1957. This is made the type of *Hirschmannia* n.g. which also contains *H. gracilis* n. comb. and *H. oryzae* n. comb. The lectotype of *H. spinicaudata* is redescribed and *Radopholus* redefined.

- 8.22. WALLACE, H. R. (1961). The orientation of *Ditylenchus dipsaci* to physical stimuli. *Nematologica*, **6**, 222-236.

In a temperature gradient of 2°-30° over 15 cm., *D. dipsaci* aggregates at about 10°. In a moisture gradient the nematodes aggregate at the end with a high moisture content and in a particle size gradient they collect in the fine particles at one end of the gradient. Light, gravity and water percolation do not affect the orientation of *D. dipsaci*, although passive directional movement may occur with the last two stimuli.

- 8.23. WALLACE, H. R. (1962). Observations on the behaviour of *Ditylenchus dipsaci* in soil. *Nematologica*, **7**, 91-101.

The vertical distribution of *D. dipsaci* in soil in an infested oat plot resembled that of other nematodes except that, after rain, the numbers of *D. dipsaci* at the surface increased greatly. *D. dipsaci* migrated to the surface of the soil and could survive drying in an atmosphere of 50% relative humidity for 34 days, equivalent to a soil moisture tension of pF 6 in a dry soil. When infested plants were wetted many *D. dipsaci* emerged. This nematode moved farther in a sandy loam than in a clay soil, but oat seedlings were invaded at similar rates in a clay loam and a sandy loam.

Insecticides and Fungicides Department

GENERAL PAPERS

- 9.1. (CROMBIE, L.) & ELLIOTT, M. (1961). Chemistry of the natural pyrethrins. *Fortschr. Chem. org. Naturst.*, **19**, 120.
- 9.2. MCINTOSH, A. H. (1961). Physical conditions affecting *in vitro* fungistatic action on conidia of *Botrytis fabae* Sardiña. S.C.I. Monogr. No. 15, p. 37.
- 9.3. POTTER, C. (1961). The future of chemical control of insects. *Ann. appl. Biol.*, **49**, 391-402.
- 9.4. POTTER, C. & BARDNER, R. (1961). The Protection of Seed: Modern methods in use both before and after sowing. *Article 7449, Central Office of Information, London.*
- 9.5. WAY, M. J. (1961). Crop losses by insects and the problem of control. *Proc. Nutr. Soc.*, **20**, 5-11.

RESEARCH PAPERS

- 9.6. ELLIOTT, M. (1961). La distillation moléculaire des Pyréthrinés. *Feuilles d'Information du Comité Français pour l'Etude des Applications des Pyréthrinés*, No. 5, 6.

The problems of separating the four colourless high-boiling unstable insecticidal constituents of pyrethrum extract from highly coloured, inert contaminants are discussed.

By the process of molecular distillation a 25% extract gives a pale-coloured distillate containing 65% of pyrethrins, a low-boiling forerun with 2-3% of pyrethrins and leaving undistilled a residue with only low biological activity.

Physical and chemical analyses show that there is little if any degradation or thermal isomerisation under the conditions used, and bioassays detect no loss of insecticidal activity in the process.

- 9.7. ELLIOTT, M. & JEFFS, K. A. (1961). A synthesis of calythrone. *Proc. chem. Soc., Lond.*, 374.

Calythrone, 3, 4-dimethyl-2-isovalerylcyclopent-4-ene-1, 3-dione, found in *Calythrix tetragona* Lab., was synthesised by condensation of dimethyl dimethylmaleate with isobutyl methyl ketone in the presence of sodium hydride. It has insecticidal activity.

- 9.8. (INNES, N. L.) & LAST, F. T. (1961). Cotton disease symptoms caused by different concentrations of *Xanthomonas malvacearum*. *Emp. Cott. Gr. Rev.*, **38**, No. 1, 27-29.

Increasing concentrations of inoculum increased the size and severity of individual lesions. Differences were larger on susceptible cotton varieties than on resistant types.

- 9.9. LAST, F. T. (1961). Direct and residual effects of *Striga* control treatments on sorghum yields. *Trop. Agric., Trin.*, **38**, No. 1, 49-56.

Sorghum crops were grown in 1958 to assess the residual effects of treatments applied in 1957 to control *Striga hermonthica*. Trap cropping with Sudan grass for 5 weeks, but not for 3, significantly decreased the incidence of *S. hermonthica* and increased grain yields of sorghum planted in both 1957 and 1958 by 500 lb./acre; in the first season straw yields were decreased.

Spraying, two to three weeks after planting, with 0.8-1.6 lb./acre of the sodium salt of 2:4-dichlorophenoxyacetic acid delayed the emergence of *S. hermonthica* and increased sorghum grain and straw yields in 1957, but had no residual effect in 1958.

Giving 80 lb. nitrogen and 40 lb. phosphorus pentoxide per acre in 1957 increased yields of sorghum in 1957 and 1958. The increases in the first season varied with the dates of application; nitrogen and phosphorus given at sowing, and 3, 6, and 9 weeks later, increased grain yields from 905 to 3,510, 3,790, 3,000 and 1,440 lb./acre respectively. In 1958 the residual effect, an increase from 2,150 to 3,210 lb./acre of grain, was the same for all dates of application. The incidence of *S. hermonthica* was not significantly affected by fertilisers in 1957, but less developed in 1958 where nitrogen and phosphorus were given in 1957.

- 9.10. LAST, F. T. & NOUR, M. A. (1961). Cultivation of *Vicia faba* L. in Northern Sudan. *Emp. J. exp. Agric.*, **29**, No. 113, 60-72.

Winter-sown broad beans in the north of the Sudan became heavily infested with *Leveillula taurica*, *Erysiphe umbelliferarum* and *E. polygoni*. Spraying with lime sulphur, two or three times per season, decreased the incidence of these powdery mildews, and increased yields by 23%. Sulphur sprays were as effective as lime sulphur, but "Karathane" did not significantly increase yields.

Spraying increased the yields most with beans sown at the optimal date. Varying the concentrations of lime sulphur from 1 in 80 to 1 in 120 v/v, and increasing the frequency of spraying from every third week to weekly did not affect yields.

At Shambat the highest yields, in two of three experiments, were given by crops sown at the beginning of November—earlier sowings are usually severely infested by insects. At Zeidab, 170 miles north of Shambat, high yields were given by crops sown from mid-October to early November. The yields of delayed plantings were much lower.

Nitrogen fertiliser significantly increased mean yields. The increases were twice as large on sprayed as on unsprayed crops, and were smaller on crops sown at the optimum time than on those sown on other dates. Phosphorus and potassium separately did not affect yields, but together they increased them as much as nitrogen.

At Shambat doubling the usual seed-rate of the local variety of beans increased yields by 48%. On introduced varieties, which yielded less, the effect was smaller.

- 9.11. LORD, K. A. (1961). The partial purification and properties of a cholinesterase from *Blattella germanica* L. *Biochem. J.*, **78**, 483-490.

A purified preparation of cholinesterase was obtained from *Blattella germanica*. The purification was 40-fold and the yield 32%. The enzyme has a high affinity for acetylcholine and is inhibited by high concentrations of this and analogous esters. Various salts activate the enzyme at high concentrations of acetylcholine, and under some circumstances inhibit at low substrate concentrations. The enzyme hydrolyses phenyl and triglyceryl esters as well as choline esters. Esters of acetic acid and propionic acid are hydrolysed much more rapidly than those of butyric acid. The enzyme showed optimum activity to acetylcholine and the acetyl and propionyl esters of phenol over a wide pH range. The properties of the enzyme are characteristic of the type of cholinesterases frequently associated with nervous tissues, and are compared with those reported for cholinesterases from insect and other sources.

- 9.12. LORD, K. A. & SOLLY, S. R. B. (1961). Changes in the amino acid content of house flies after organophosphorus poisoning. *Chem. & Ind.*, 1359-1360.

House flies contain some free amino acids, the relative amounts of which may be specific for different strains of insects. When poisoned with organophosphorus insecticides the amounts of these amino acids change. The most obvious effect is a decrease in the free α -alanine. The changes observed seem to be specific for organophosphorus poisoning.

- 9.13. LORD, K. A. & (RASMUSON, B.) (1961). Phospholipid content in different strains of *Drosophila melanogaster* and the tentative relation to resistance to organophosphorus compounds. *K. LantbHögsk. Ann.*, 27, 343-350.

This was a preliminary investigation using two strains of *D. melanogaster*, one susceptible to, the other resistant to, organophosphorus insecticides. The phospholipids were extracted in a 2:1 chloroform-methanol mixture, then purified and partially separated by absorption on and elution from silicic acid or alumina. The phosphorus and nitrogen contents of the fractions were assayed and showed that the two strains differed in phospholipids.

- 9.14. MCINTOSH, A. H. (1961). Effects of time and temperature on the fungistatic action of mercury-containing and other compounds on conidia of *Botrytis fabae* Sardiña. *Ann. appl. Biol.*, 49, 433-444.

The *in vitro* fungistatic action of nineteen compounds was measured on conidia of two strains of *Botrytis fabae* Sardiña in slide-germination tests, at two or three incubation temperatures in the range 10°-25° C.; the effects were assessed at intervals up to 14 days from the start of each test.

In general, the ED50's increased as incubation time passed, finally approaching or reaching steady values. With each compound, an increase in incubation temperature increased the speed of action (i.e., decreased the time taken for the ED50 to reach a steady value), and increased the ultimate toxicity. Temperature coefficients were calculated as ratios of ED50's and were "positive" or "negative" according to whether the toxic action was greater or less at the higher temperature.

The conidia of the two strains of *B. fabae* behaved similarly, but the temperature coefficients were larger with one strain (A) than the other (B).

Mercuric cyanide, chloride, bromide, acetate and thiocyanate gave positive coefficients which increased in size as incubation time passed. In these tests, which lasted for only 3 days, the largest 10:25° C. coefficient (+35) was given by the cyanide after 3 days (strain A); the corresponding figures for the chloride and bromide were +10.5 and +6.0. Phenyl mercury acetate, methyl mercury nitrile, silver nitrate, copper sulphate, 8-hydroxyquinoline, acetamide, *p*-nitrophenol, 2:4-dinitrophenol and pentachlorophenol gave coefficients which were usually small and positive (about +1.3), and changed only slightly in size as incubation time passed. *t*-Butyl alcohol, pyridine, 3-picoline, phenol and *p*-chlorophenol gave coefficients which changed from negative (-3.9 to -1.5) to positive (+1.3 to +3.2) after 2-7 days (strain B).

There was little evidence that spores are more resistant to fungicides at their optimum temperature for germination, i.e., the temperature at which maximum germination is reached soonest (15-20° C. for *B. fabae*).

Mercuric cyanide, chloride and bromide, which are scarcely ionised in aqueous solution, also resembled non-electrolytes in that the sizes of their positive temperature coefficients were inversely related to their solvent: water partition coefficients, i.e., the temperature coefficients increased with decrease in the presumed rates at which lipid membranes are penetrated by diffusion. This correlation did not extend to other compounds.

- 9.15. MOLLOY, FRANCES M. (1961). The histochemistry of the cholinesterases in the central nervous system of susceptible and resistant strains of the house fly, *Musca domestica* L., in relation to diazinon poisoning. *Bull. ent. Res.*, 52, 667-681.

Inhibition of cholinesterase in the central nervous system of *M. domestica* after poisoning with diazinon is confined to certain parts of the ganglia; other

parts remain unaffected even after death. Total inhibition is rarely seen. This indicates that, if cholinesterase inhibition is the cause of death, a local rather than a general inhibition is involved. The extent of inhibition after poisoning differed in strains differing in their resistance to diazinon poisoning.

- 9.16. SAWICKI, R. M. (1961). The effect of "Safroxan" on the knock-down and the 24 hr. toxicity of commercial pyrethrum extract against house flies (*Musca domestica* L.). *Pyrethrum Post*, **6**, No. 2, 38-42.

The effectiveness of pyrethrum extract with "Safroxan" at 1:10 w/w against house flies during the first 15 minutes and 24 hours after treatment was compared with the effectiveness of a similar mixture of pyrethrum extract with piperonyl butoxide, and also with the extract alone. The flies, held during the treatment by suction, were treated topically with a measured drop of the substance tested.

Safroxan did not increase the effectiveness of pyrethrum during the first 15 minutes after treatment; it increased the toxicity of the extract 24 hours after treatment by about 3.5 times. Piperonyl butoxide, under similar conditions, slightly increased the knock-down activity of the extract (synergistic factor 1.9, 15 minutes after treatment); it increased the toxicity of the extract 24 hours after treatment very considerably (synergistic factor 9.6).

- 9.17. SAWICKI, R. M. (1962). Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. II. Synergistic activity of piperonyl butoxide with the four constituents. *J. Sci. Fd Agric.*, **13**, 260.

The toxicity to female house flies, 5-6 days old of the four insecticidal constituents of pyrethrum, combined at six ratios (from 1:0.1 to 1:20 w/w) with piperonyl butoxide, was determined by a measured drop technique. The order and magnitude of the toxicities of the synergised constituents (relative to synergised pyrethrum extract) vary with the amount of synergist present. At 1:8 (pyrethroid:piperonyl butoxide) the relative toxicities of the four constituents were: pyrethrum extract 1.0 (1.0), pyrethrin I 1.31 (0.85), cinerin I 1.28 (0.53), pyrethrin II 0.90 (1.37), cinerin II 0.58 (0.49). The relative toxicities of the constituents alone are given in brackets. At this ratio the synergistic factors of the four constituents were: pyrethrin I 18, cinerin I 27, pyrethrin II 6, cinerin II 14, pyrethrum extract 10. Possible explanations for differences of the extent to which the constituents are synergised are discussed.

- 9.18. SAWICKI, R. M., ELLIOTT, M., GOWER, J. C., (SNAREY, M. & THAIN, E. M.) (1962). Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. I. Preparation and relative toxicity of the pure constituents; statistical analysis of the action of mixtures of these components. *J. Sci. Fd Agric.*, **13**, 172-185.

Pyrethrin I and II and cinerin I and II were isolated from commercial extract by displacement chromatography and also reconstituted from the naturally derived acids and alcohols. The four constituents from both sources had identical chemical, physical and insecticidal properties. The relative toxicities of the four constituents to female house flies (*Musca domestica* L.) determined by a measured-drop technique were: pyrethrum extract 1.0, pyrethrin II 1.3-1.5, pyrethrin I 0.9-1.0, cinerin II 0.5-0.6, cinerin I 0.4-0.5. The insecticidal activity of a mixture of the four constituents was tested statistically for simple similar joint action, when the probit lines are not parallel; the predicted results are in good agreement with the experimental data. The procedures for computing simple similar joint action are discussed and included in an appendix.

- 9.19. SAWICKI, R. M. & HOLBROOK, DAPHNE V. (1961). The rearing, handling and biology of house flies (*Musca domestica* L.) for assay of insecticides by the application of measured drops. *Pyrethrum Post*, **6**, No. 2, 3-18.

The recent work on the biology and breeding techniques of house flies is reviewed.

Techniques are described for breeding house flies (*Musca domestica* L.) in pairs, small numbers (10–100) and on a large scale, as well as methods for handling, immobilising and treating the adult females with a measured-drop technique. The egg-laying medium consists of cotton-wool rolls soaked in a solution of milk and yeast. The eggs are separated in water from the egg-laying medium and are seeded on to the larval medium, which is made of 100 g. milk powder, 100 g. dried yeast, 20 g. agar, all made up in 1.0 l. of boiling water. The medium is then covered with saw-dust. The larvae which pupate in the saw-dust layer are separated from the medium by flotation in water. The adults are fed on dry milk powder and granulated sugar, liquid milk and a sugar solution. The full breeding cycle takes exactly a fortnight at 25.5°–26.5° C. For bio-assays the flies are cooled for 20 minutes at –20° C., then sexed in a cooling cabinet at 5°–10° C. The females are sorted into Petri dishes (15–20 flies per dish) and fed with a milk paste and sugar solution. They are left to recover at the required temperature. On the following day they are immobilised by chilling at –8° C. for a short time and are treated by topical application. They are replaced at the required temperature until death end-point is reached. Repeated experiments with this technique under identical conditions give reliable results.

- 9.20. WAY, M. J. (1960). The effects of freezing temperatures on the developing egg of *Leptohylemyia coarctata* Fall. (Diptera, Muscidae) with special reference to diapause development. *J. Insect. Physiol.*, **4**, 92–101.

The later stages of diapause in the egg of *L. coarctata* are completed rapidly at –20° to –24° C. At –24° C. the rate of diapause completion is about 180 times faster than at –6° C. and about 80 times faster than at 3° C. These results suggest that there are at least two phases in diapause development—an initial synthesis, perhaps of neurohormone, which will not occur at –18° to –20° C. This is followed by a process ending in release of the synthesised material, which is greatly accelerated by relatively short exposures at –20° to –24° C.; longer exposures kill the eggs, probably because they freeze.

- 9.21. WAY, M. J. (1961). Bean aphid control on field beans in relation to the flowering period and to honey bee poisoning. *Plant Path.*, **10**, No. 1, 14–20.

Insecticides applied at the best time for controlling bean aphid are especially dangerous to bees on February-sown crops, because these are likely to be in full bloom when they need spraying. Crops sown at other times will usually have flowered or not yet flowered, though some bees may be visiting them for extra-floral nectar.

Most spring bean crops are sown in March or April, and the main danger to bees seems to be from the unnecessarily late spraying of such crops.

Entomology Department

DOCTORAL THESES

- 10.1. COCKBAIN, A. J. (1961). Physiological studies on the flight of *Aphis fabae* Scop. Ph.D. Thesis, University of London.
- 10.2. MADGE, D. S. (1961). Some aspects of the ecology and physiology of free-living mites. Ph.D. Thesis, University of London.

GENERAL PAPERS

- 10.3. ARNOLD, M. K. (1961). Bibliography of H. F. Barnes (1902–1960). *J. Soc. Bibl. nat. Hist.*, **4** (1), 35–43.
- 10.4. BANKS, C. J. (1959). Effects of ants on the physiology and development of aphids. In *The Ontogeny of Insects. Acta Symposii de evolutione Insectorum*. Praha, 1959, pp. 329–332.

- 10.5. BANKS, C. J. (1960). Some recent studies, involving the use of radioisotopes, of the feeding behaviour of two phytophagous insects. *Proc. of Int. Atomic Energy Agency. Symposium on Radioisotopes and Radiation in Entomology, Bombay, 1960*, pp. 175-180.
- 10.6. EDWARDS, C. A. (1961). Glasshouse Symphylids. *Minist. Agric. advisory Leaflet*, 484, 1-6.
- 10.7. HEATH, G. W. (1961). Soil fauna investigations. *Rep. For. Res. for 1960*, 94-95.
- 10.8. JOHNSON, C. G. (1960). The present position in the study of insect dispersal and migration. *Rep. 7th Commonw. entom. Conf. London 1960*, pp. 140-145.
- 10.9. JOHNSON, C. G. (1961). Aphid dispersal and its bearing on the general character of insect migration by flight. *Anim. Behav.*, 9, 3-4.
- 10.10. JOHNSON, C. G. (1961). Capsids: a review of current knowledge. In *Agriculture and Land Use in Ghana* (ed. J. B. Wills) London: Oxford University Press, pp. 316-331.
- 10.11. JOHNSON, C. G. (1961). The ecological approach to cocoa disease and health. In *Agriculture and Land Use in Ghana* (ed. J. B. Wills) London: Oxford University Press, pp. 348-352.
- 10.12. RAW, F. (1961). The agricultural importance of the soil mesofauna. *Soils and Fert.*, 24, 1-2.

RESEARCH PAPERS

- 10.13. BANKS, C. J., (BROWN, E. S. & DEZFULIAN, A.). (1961.) Field studies of the daily activity and feeding behaviour of Sunn Pest, *Eurygaster integriceps* Put., (Hemiptera, Scutelleridae) on wheat in North Iran. *Ent. exp. & appl.*, 4, 289-300.

Individual Sunn Pests were tagged with Ta¹⁸² and their position recorded every $\frac{1}{2}$ hour during daylight. At the beginning of the feeding period in early June they spent most of the time feeding on wheat ears, or in cracks in the soil when the air was hot and dry and the wheat dry and ripe. At the end of the feeding period in late June and just before migrating, long periods were spent in soil cracks, the insects moving actively but feeding infrequently.

Feeding began after sunrise, with two maxima, at 0800 hours and in the afternoon; it ceased at sunset, and there was little movement after dark. Feeding and air temperature were not simply correlated. Distribution of the pest in dry wheat near harvesting was associated with the distribution of two species of green weeds on which the insects fed.

- 10.14. BARNES, H. F., ARNOLD, M. K. & HEATH, G. W. (1962). The gall midges of wild ox-eye daisy (*Chrysanthemum leucanthemum* L.) flowers, with the description of a new species. *Trans. Soc. Brit. Ent.*, 15 (1).

Four important gall midges, *Clinorrhyncha leucanthemi* Kieffer, *Dasyneura chrysanthemi* sp. n., *Rhopalomyia hypogaea* F. Loew and *Contarinia chrysanthemi* Kieffer, and three species of *Clinodiplosis*, *Lestodiplosis* and *Phaenobremia*, have been recorded from wild ox-eye daisy flowers. Their taxonomy, distribution, biology and host-plant range are discussed, and a key is given for their separation.

(The material in this paper was collected by Dr. H. F. Barnes in 1952/53 when searching for the source of a gall midge pest of cultivated Chrysanthemums; the paper was completed after Dr. Barnes' death.)

- 10.15. COCKBAIN, A. J. (1961). Low temperature thresholds for flight in *Aphis fabae*. *Ent. exp. & appl.*, **4**, 211-219.

The temperature thresholds for wing-beating and successful flight in alienicolae of *Aphis fabae* were found by flying tethered aphids in a falling temperature and by dropping free aphids in still air at different temperatures. The medium temperature thresholds for wing-beating, horizontal and upward flight were 6.5°, 13° and 15° respectively.

- 10.16. COCKBAIN, A. J. & HASTIE, A. C. (1961). Susceptibility of the bed bug, *Cimex lectularius* Linnaeus, to *Aspergillus flavus* Link. *J. Insect Path.*, **3**, 95-97.

Bed bugs kept at 30° and 90% relative humidity become naturally infected with *Aspergillus flavus* Link; this is apparently the first record of a fungus pathogenic to the bug. Infected second-instar and adult bugs lived for a significantly shorter time than non-infected controls.

- 10.17. EDWARDS, C. A. & (GUNN, E.). (1961.) Control of the Glasshouse Millipede. *Plant Path.*, **10**, 21-24 and Plate IV.

This millipede (*Oxidus gracilis* Koch) is essentially tropical and often attains excessively high numbers in glasshouses (500 millipedes/sq. ft. of cucumber bed in one house). Observations on its biology and experiments on its control were made in glasshouses and laboratory. Materials tested were naphthalene, nicotine, parathion, lindane, dieldrin, diazinon, "Phosdrin" and aldrin. Naphthalene, nicotine, parathion and lindane gave quick initial kill, but their effects did not persist; lindane and dieldrin acted slower, but their effects persisted for months. The most effective was to drench soil, later covered with a polythene sheet, with a mixture of lindane and nicotine.

- 10.18. EDWARDS, C. A. & (DENNIS, E. B.) (1961). Phytotoxicity of insecticides and acaricides. I. Foliage sprays. *Plant Path.*, **10**, (2), 54-60.

Commonly used pesticides at once, twice and five times the normal dosage were sprayed on the foliage of some outdoor and indoor crops, for which they would normally be recommended, both with and without a wetter, and effects on the crops recorded. Of the more widely used commercial materials DDT, aldrin, dieldrin, "Roger," TEPP and parathion caused most damage, and phenkapton, fenson, chlorbenside, fluoracetamide, "Kelthane," "Phosdrin" and lindane caused some. The safest material tested was demeton methyl, which damaged no crop. Crops tested were peas, beans, lettuce, fodder beet, strawberries, cabbage, tomatoes, cucumbers. Cucumber was by far the most susceptible to damage, and cabbage and fodder beet were seldom harmed. Organophosphorus materials tended to produce edge chlorosis and scorch, which was also seen with malathion and diazinon. The chlorinated hydrocarbons usually caused distortion, leaf curl and leaf droop. At the highest dosages most materials severely affected growth and commonly caused necrosis.

- 10.19. EDWARDS, C. A. (1961). The ecology of Symphyla. Part III. Factors controlling soil distributions. *Ent. exp. & appl.*, **4** (4), 239-256.

Symphylids exhibit complex, seasonal, vertical migrations in soil. An attempt was made to assess the relative importance of different environmental and endogenous factors affecting these migrations; soil moisture content, soil temperature, the presence of plants at the soil surface, feeding cycles, moulting cycles, egg-laying and diurnal rhythms were studied in field and laboratory. Distributions of symphylids were correlated with soil moisture, and where this was equivalent to a relative humidity of less than 100% in the soil air, symphylids migrated to other soil layers. Symphylids survived long periods only in air of 100% relative humidity. The zone of optimum temperature for symphylids lies between 15° and 21°, and the survival zone is 2°-28°. *Scutigera immaculata*, a phytophagous species, would enter a zone to feed where soil conditions were unfavourable. This species, which had feeding and non-feeding phases, migrated to deeper soil during non-feeding phases and for moulting.

Eggs were commonly laid at 5–15 cm. in the soil. No diurnal rhythm was found. Conditions favouring symphyllids at the soil surface were the presence of plants there, much moisture and temperatures between 15° and 21°.

- 10.20. HEATH, G. W. (1961). An investigation into leaf deformation in *Medicago sativa* caused by the gall midge *Jaapiella medicaginis* Rübsaamen (Cecidomyiidae). *Marcellia*, **30**, Suppl., 185–221.

In simple leaf galls caused by the lucerne leaf midge *Jaapiella medicaginis* Rüb. the layer of cutin secreted by the epidermal cells within the larval chamber begins to disappear once the larva has hatched, and is soon lost from all the epidermal cells lining the larval chamber. The destruction of the cuticular layer presumably makes the epidermis permeable to the passage of solutes which stimulate gall formation.

- 10.21. HEATH, G. W. (1962). The influence of ley management on earthworm populations. *J. Brit. Grassl. Soc.* (In the press.)

Results are given of 4 years' sampling for earthworms on a ley management experiment at Hurley, Berks. Both weight and numbers of earthworms increased in the ley, more so when grazed than when cut. The significance of this increase in terms of soil fertility and crop productivity is discussed.

- 10.22. JOHNSON, C. G. (1961). Syrphid (Dipt.) migration on the Norfolk Coast in August, 1960. *Ent. mon. Mag.*, **96** (1960), 196–7.

A low-level, orientated mass migration of sexually immature *Syrphus luniger* Mg. and *S. corollae* F. is described.

- 10.23. JOHNSON, C. G., TAYLOR, L. R. & SOUTHWOOD, T. R. E. (1962). High altitude migration of *Oscinella frit* L. (Diptera, Chloropidae). *J. anim. Ecol.* (In the press.)

The vertical distribution in the atmosphere of panicle generation adults of *O. frit* was measured up to 1,000 feet for each hour during several days in August 1955. The relative density in the upper air in the early morning is low; it increases towards midday as turbulence and convection in the atmosphere increase and decreases again towards late afternoon. Maximum numbers in flight coincide with maximum upward transport, and the median height of flight (above which 50% of the airborne population fly) was about 1,300 feet at that time. Frit fly is thus adapted for high-altitude dispersal.

- 10.24. MADGE, D. S. (1961). The control of relative humidity with aqueous solutions of sodium hydroxide. *Ent. exp. & appl.*, **4**, 143–147.

A gravimetric method is described for producing graded aqueous solutions of sodium hydroxide to give atmospheric relative humidities in steps of 10% between 0° and 40°.

- 10.25. MADGE, D. S. (1961). "Preferred temperatures" of land arthropods. *Nature, Lond.*, **190**, 106–107.

- 10.26. MADGE, D. S. (1961). The behaviour of free-living mites as affected by humidity. *Anim. Behav.*, **9**, 108.

Oribatid mites from various habitats behaved as "indicators" of the habitats. Thus a xerophil species chose dry humidities initially and higher humidities after 4 days. A mesophil species chose a high humidity initially, and a hygrophyl species did not react to linear or alternative humidity gradients. To a certain extent, starvation, desiccation and other internal and external factors changed responses to humidity. Individual mites differed from groups in their behaviour. The hygroreceptors are on the forelegs.

- 10.27. TAYLOR, L. R. & CARTER, C. I. (1961). The analysis of numbers and distribution in an aerial population of Macrolepidoptera. *Trans. R. ent. Soc. Lond.*, **113**, 369-386.

In three seasons' suction trapping at five heights population structure was very consistent. Moths occasionally reached very high densities, comparable in biomass with aphid migrations. Diurnal flight periodicity and height of flight were highly specific. Light traps selected some species 5,000 times as strongly as others, but their efficiency varies so much during the night that they are useless for measuring flight periodicity. With a suction-trap catch of only 169 specimens in 3 years, the flight temperature threshold, height of flight, diurnal periodicity and phenology of *Agrochola lychnidis* were accurately defined.

Bee Department

GENERAL PAPERS

- 11.1. BAILEY, L. (1961). European foulbrood. *Amer. Bee J.*, **101**, 89-92.
- 11.2. FREE, J. B. (1961). The orientation of honeybees to their hives. *Anim. Behav.*, **9**, 231 only.
- 11.3. FREE, J. B. (1961). The social organisation of the bumblebee colony. *Rep. cent. Ass. Brit. Beekeep. Ass.*, 1-11.
- 11.4. SIMPSON, J. (1961). Nest climate regulation in honey bee colonies. *Science*, **133**, 1327-1333.

RESEARCH PAPERS

- 11.5. BAILEY, L. (1961). An improved medium for the isolation of *Streptococcus pluton* (White). *J. Insect Path.*, **3**, 100 only.

Including soluble starch in the special medium necessary to cultivate *S. pluton* greatly facilitates its isolation, but is usually unnecessary for its subsequent propagation.

- 11.6. BAILEY, L. (1961). The natural incidence of *Acarapis woodi* (Rennie) and the winter mortality of honey bee colonies. *Bee World*, **42**, 96-100.

The incidence of *Acarapis woodi* at Rothamsted decreased strikingly after seasons of good nectar-flow. The mortality of colonies in winter was not obviously correlated with infestation except in the few colonies with more than 50% of bees infested. There was no obvious difference between the susceptibility of bees of three different origins to infestation. Less than 2% of colonies in England and Wales are estimated to suffer measurably from *A. woodi*.

- 11.7. BUTLER, C. G. (1961). The scent of queen honeybees (*A. mellifera* L.) that causes partial inhibition of queen rearing. *J. Insect Physiol.*, **7**, 258-264.

Virgin queens, like mated, laying ones, produce a scent that partially inhibits worker bees from rearing queens. When this scent and enough of the queen's other inhibitory factor, 9-oxodecenoic acid, are present together inhibition is complete. Old, mated, laying queens produce more inhibitory scent than virgins, which produce similar amounts irrespective of their age. Like 9-oxodecenoic acid, the inhibitory scent occurs all over a queen's body. Unlike this acid, which is produced mainly in a queen's mandibular glands, the inhibitory scent probably comes from glands in many parts of her body. The inhibitory scent is probably distinct from the attractive scent.

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- 11.8. BUTLER, C. G. (CALLOW, R. K. & JOHNSTON, N. C.). (1961.) The isolation and synthesis of queen substance, 9-oxodec-*trans*-2-enoic acid, a honeybee pheromone. *Proc. Roy. Soc. B.*, **155**, 417-432.

A method is described for isolating "queen substance", which is produced in the mandibular glands of queen honeybees and inhibits both queen rearing by worker honeybees and the development of their ovaries. Queen substance was identified as 9-oxodec-*trans*-2-enoic acid and its identity confirmed by synthesis. The synthetic and natural materials have the same biological activity. The methyl ester of 9-oxodecenoic acid is also active.

Neither the natural nor the synthetic material completely inhibits queen rearing, whereas the presence of a live queen does. The other inhibitory factor is "queen scent", which also on its own does not completely inhibit queen rearing. Queen scent plus 9-oxodecenoic acid cause complete inhibition.

9-oxodecenoic acid did not affect the reproduction of any of the small mammals on which it was tested; nor did it have any pharmacological activity in a wide range of tests.

- 11.9. FREE, J. B. (1960). The behaviour of honeybees visiting flowers of fruit trees. *J. Anim. Ecol.*, **29**, 385-395.

Foraging bees were watched on apple, apricot, peach, pear, plum and sweet cherry flowers. During a single flower visit a bee either approached the nectary from the top of the stamens, sometimes collecting pollen in the process, or scabbled over the anthers and gathered pollen only, or, far less often, did both. Bees also obtained nectar from apple flowers by inserting their tongues between the filaments of the stamens from the side, often without touching the anthers; the proportion of nectar-gatherers that visited apple flowers in this way varied with the flexibility, height and thickness of the filaments of the variety concerned.

During a single trip, or part of a trip, most bees kept to one type of behaviour, but some collected pollen only on some flower visits and nectar, with or without pollen, on others. The proportions of the different types of flower visits varied from day to day and at different times on the same day.

Bees visited an average of about two trees per trip and tended to change to trees nearest to those on which they started working. Except on pears, pollen-gatherers spent less time per flower and visited more flowers per tree than nectar-gatherers. On unfavourable days bees spent longer per flower and visited fewer flowers per tree.

- 11.10. FREE, J. B. (1960). The distribution of bees in a honey-bee (*Apis mellifera* L.) colony. *Proc. R. ent. Soc. Lond. A*, **35**, 141-144.

Bees of all age groups were almost equally distributed on combs of young larvae, old larvae and eggs. The lowest percentages of bees with undeveloped hypopharyngeal glands were on the combs of larvae, and the highest percentages with developed glands on the food stores, combs of sealed and emerging brood and on combs of larvae. It is, therefore, improbable that nurse bees of different ages feed larvae of different ages. An individual worker may vary the composition of its glandular secretion to suit the age of the larva concerned, or, less probably, the glandular secretion differs in individual bees irrespective of their ages.

- 11.11. FREE, J. B. (1961). Hypopharyngeal gland development and division of labour in honey-bee (*Apis mellifera* L.) colonies. *Proc. R. ent. Soc. Lond. A*, **36**, 5-8.

Confining newly emerged workers for different lengths of time, and on different diets, changed the development of their hypopharyngeal glands and the ages at which they began foraging.

- 11.12. FREE, J. B. (1961). The stimuli releasing the stinging response of honeybees. *Anim. Behav.*, **9**, 193-196.

The factors inducing honeybees to sting were investigated by comparing the number of times cotton-wool balls treated in different ways were stung.

Dark-coloured balls were stung more than light-coloured, particularly against dark backgrounds, and materials of rough texture were stung more readily than smooth. Increasing rate of movement increased stinging.

The odour associated with sting venom encouraged further stinging. This odour could be masked by smoke. General bee odour encouraged stinging little, if at all, and bees were more inclined to sting balls with the odour of their own than of another colony. Animal scent and the smell of human perspiration encouraged stinging and various insect repellents discouraged it.

- 11.13. FREE, J. B. & SPENCER-BOOTH, YVETTE. (1960.) Chill-coma and cold death temperatures of *Apis mellifera*. *Ent. exp. & appl.*, **3**, 222-230.

Worker bees have a lower chill-coma temperature than drones or queens; it is influenced by their acclimatisation temperature, as is their food consumption at a given temperature. Most bees die after fifty hours in chill-coma and survive longer at 5° than at 0° or 10°. Cold death occurs between -2° and -6° and is unaffected by acclimatisation. "Winter" bees have lower chill-coma temperatures than "summer" bees, but after acclimatisation to 35° there is no difference. The chill-coma temperature of "summer" bees decreases with age, irrespective of acclimatisation.

- 11.14. FREE, J. B. & SPENCER-BOOTH, YVETTE. (1961.) Further experiments on the drifting of honey-bees. *J. agric. Sci.*, **57**, 153-158.

Worker bees learned the colour of their hive close to the hive entrance and took little or no notice of colours above the lower brood-chamber. They orientated to a colour below the entrance more than to one above. They did not learn combinations of colours. They distinguished between certain symbols placed immediately above the hive entrance and learned the height of their hive and the height of its entrance above ground.

More worker bees and drones from queenright colonies drifted to queenless than to queenright colonies. Drones expelled from queenright colonies did not drift to queenless ones.

- 11.15. FREE, J. B. & SPENCER-BOOTH, YVETTE. (1961.) The effect of feeding sugar syrup to honey-bee colonies. *J. agric. Sci.*, **57**, 147-151.

In the spring, summer and autumn of 1958 and 1959, colonies were fed concentrated (62%) or dilute (40%) sugar syrup, or remained unfed. They were observed for the week before, during and after feeding. The amount of syrup taken increased during the year, more of the concentrated than of the dilute being taken, but this ratio decreased during the year. The concentration fed made no apparent difference to colony gain in weight relative to the sugar taken. Feeding increased brood rearing in 1958 (bad weather), but not in 1959 (good weather). It usually increased pollen-collection but feeding concentrated syrup probably decreased nectar-gathering.

- 11.16. FREE, J. B. & SPENCER-BOOTH, YVETTE. (1961.) Analysis of honey farmers' records on queen rearing and queen introduction. *J. agric. Sci.*, **56**, 325-331.

Sealed queen cells and virgin queens were accepted better by colonies which had queen cells, or had been queenless more than two days, than by colonies without sealed queen cells. Younger queen cells were better accepted than older ones in recently dequeened colonies. Mated, laying queens were less successfully introduced to colonies which previously had virgin queens, queen cells, or laying queens and queen cells, than to colonies that previously had laying queens only. Thus, success was greatest when the queen removed from the recipient colony was at the same, or immediately previous, stage of development as the queen being introduced. In June and July introduction of queen cells and virgin queens was more successful, and that of mated, laying queens less successful, than in May and August, suggesting the importance also of the physiological state of the colony.

- 11.17. FREE, J. B. & SPENCER-BOOTH, YVETTE. (1961.) Effect of temperature on *Apis indica* workers. *Nature, Lond.*, **190**, 933.

Small groups of *A. indica* workers, like those of *A. mellifera*, respond to low temperature by taking more food, indicating increased metabolism and heat production. The mortality of both species was similar at high temperatures, but was greater for *A. indica* at low temperatures. *A. indica* workers have a higher chill-coma temperature than *A. mellifera*. These results indicate that *A. mellifera* is better adapted to temperate climates than *A. indica* but fail to show that *A. indica* has any corresponding adaptation to the tropics.

- 11.18. RIEDEL, I. B. M. & SIMPSON, J. (1961). Absence of salivary invertase in queen and drone honey bees. *Experientia*, **17**, 365.

Queens and drones have little, if any, invertase in their salivary glands. They take no part in honey storage, so probably do not need the enzyme in their saliva.

Statistics Department

GENERAL PAPERS

- 12.1. HEALY, M. J. R. (1962). The place of mathematics in biology. *Biology*. (In the press.)
- 12.2. VERNON, A. J. (1961). Control of cocoa capsids in West Africa. *Chem. & Ind.*, 1219-1220.

RESEARCH PAPERS

- 12.3. BUCK, S. (1961). The use of rainfall, temperature, and actual transpiration in some crop-weather investigations. *J. agric. Sci.*, **57**, 355-365.

This paper reports various investigations of the effects of meteorological factors on the yields of crops in England and Wales. The investigations were undertaken primarily with the objects of seeing: (a) whether variations in temperature had any direct effect on yields, and (b) whether Penman's concept of actual transpiration gave a better measure of the total effect of rainfall than the use of a multiple regression on variates representing total rainfall and its distribution.

The effect of temperature and its seasonal distribution on the yields of wheat on various plots of the classical wheat experiment on Broadbalk field at Rothamsted was studied in conjunction with rainfall and its seasonal distribution, using the regression method devised by Fisher. Variations in temperature were found to show no effects on the final yields.

The relationship between actual transpiration and yield was investigated for the Broadbalk field and for sugar beet and potatoes, using average yields determined by sampling methods, for various districts in England and Wales. For sugar-beet virus yellows infection, and for potatoes blight attack, were also taken into account.

No relationship between actual transpiration and wheat yields on Broadbalk field was found, but sugar beet and potatoes both showed a positive association between actual transpiration and yield except for sugar beet in the Spalding area, where there is a high water table. Actual transpiration was in general more effective than a regression on total rainfall and its distribution accounting for variations in yield. As might be expected, virus yellows and blight also account for a good deal of the variation in yield.

- 12.4. (BURRELL, R. J. W.), HEALY, M. J. R. & (TANNER, J. M.) (1961). Age at menarche in South African reserve-domiciled Bantu schoolgirls. *Hum. Biol.*, **33**, 250-261.

The distribution of age at menarche has been studied in 47,420 Bantu schoolgirls living in the Transkei Reserve, South Africa. The girls were interviewed by women Bantu teachers and asked whether or not menstruation had occurred. Dates of birth were taken from the school admission registers and

are believed to be nearly all correct to the nearest month. The girls were divided into those coming from "poor" and those from "not-poor" homes, as judged by the school principals.

The proportions menstruating plotted against age were fitted by two alternative sigmoid curves, the cumulative Normal and the logistic. The latter gave a slightly better fit for the not-poor group and was superior for the poor group. There was an effect of month of birth, girls born early in the calendar year tending to menstruate some four months later than those born towards the end of the year. The mean age at menarche was 15.42 ± 0.04 years for the poor group and 15.02 ± 0.03 years for the not-poor group. In addition to the later mean, the poor group were more variable in age at menarche than the not-poor group.

- 12.5. (COOKE, PATRICIA, JONES, MORLEY R., MATHER, K.), BONSALE, G. W. & (NELDER, J. A.). (1962.) Estimating the components of continuous variation. *Heredity*. (In the press.)

Two inbred lines of *Drosophila melanogaster* were crossed reciprocally. In addition to the F_1 's, and F_2 's biparental progenies of the third generation were raised from both crosses. The number of sternopleural chaetae were counted in all these generations and components of variation (D, H, E_1 and E_2) for this character were estimated using the method devised by Mather (1949). Replicate estimates were obtained by using data from males and females separately in the two halves of the experiment stemming from the reciprocal crosses. The results from one sib of females proved to be aberrant for reasons which are not known. The analyses yielded no clear indication of any effect of linkage.

A weighted method which allows for differences in precision and correlation among the basic statistics has been described by Nelder (1960), and this was applied to the results. The weighted analysis provides clear evidence of the effects of linkage and also brings out more forcibly the abnormality of the results for the aberrant females.

The simple unweighted analysis yields estimates of the components of variation which do not differ significantly from those resulting from the weighted analysis. The relative efficiency of the unweighted analysis varies from 60% to over 90% for the various components of variation over the four parts of the experiment.

A further set of data for flowering time and plant height in *Nicotiana rustica* were similarly analysed by both methods. Though the broad structure of the experiment was similar to that of the one with *Drosophila*, the relative precisions of the statistics it yielded were somewhat different. The unweighted estimates of the components stood in very much the same relation to the weighted estimates as in the *Drosophila* experiment, and the efficiency of the weighted method was also much the same.

- 12.6. (DERMOTT, W.) & LESSELLS, W. J. (1962). The use of gypsum on soils which have not been flooded by seawater. *Crop Husbandry*. (In the press.)

The effects of gypsum and lime on soil structure and crop yield were measured in fourteen experiments, on soils not flooded by sea-water but heavy in texture and on which it was difficult to obtain satisfactory tilths. Four of the experiments were on restored opencast coal sites.

Some improvement in soil structure was noted in seven out of the fourteen experiments, but it was slight and temporary. No improvement was noted following the use of ground limestone, chalk or (one experiment only) burnt lime.

In none of the experiments was there a significant yield response to gypsum or to lime, and the results as a whole are consistent with the idea that gypsum did not affect responses at any site.

- 12.7. GOWER, J. C. (1962). The handling of multiway tables on computers. *Comput. J.*, **4**, 280-286.

A notation is proposed which concisely describes many forms of table manipulation in terms of a concept called *scanning*. Methods of programming a scanning sub-routine are discussed, and examples are given of the use of the scanning notation to formulate typical table operations in symbolic form. It is often convenient to store marginal values (usually totals or means) with the

main table, and this requires some modification of the notation and the sub-routine. Proposals are outlined for including scanning facilities in automatic programming languages, and examples are given of the form this could take in a language related to the Mercury Autocode compiler.

- 12.8. HEALY, M. J. R. & GOWER, J. C. (1961). Aliasing in partially confounded experiments. *Biometrika*, **48**, 218–220.

In factorial experiments with factors at more than two levels it is common practice to employ in the scheme of confounding a set of contrasts different from those used in the analysis of the experiment. Unless the confounding is balanced, this can lead to estimates of these latter contrasts being wholly or partly correlated. Details are worked out for experiments of the type 3^n and $2^m \times 3^n$.

- 12.9. LEECH, F. B. (1962). A statistical technique suitable for the analysis of farm surveys of fertility. *Proc. Fourth Int. Congr. Animal Reproduction*. (In the press.)

After showing how to obtain an index of herd fertility adjusted for factors known to influence individual matings, the index is used (giving unit weight to each farm) to examine the effects of environment or management factors on herd fertility.

- 12.10. PATTERSON, H. D. & (WILLIAMS, R.). (1962.) The residual effects of phosphorus fertilisers on yields of arable crops: preliminary results of six rotation experiments. *Exp. Husbandry*. (In the press.)

Six long-term experiments on the direct and residual effects of four phosphorus fertilisers, superphosphate, rock phosphate, basic slag and dicalcium phosphate, on yields of arable crops are in progress at N.A.A.S. Experimental Husbandry Farms. The results of up to 7 years are summarised and discussed.

Responses to direct applications agree fairly closely with the conclusions drawn by Cooke (1956) and Cooke and Widdowson (1959) from many 1-year experiments. Superphosphate gave consistently good responses, but the more insoluble fertilisers can give poor results. Thus, rock phosphate was of little or no value for any of the crops tested on neutral soils and gave relatively small increases in yields of potatoes on acid soils. With such soils the efficiency of rock phosphate decreased as the rate of application increased. Basic slag also gave poor yields of potatoes except on one acid soil. Dicalcium phosphate gave the best yields of potatoes, the only example of the less-soluble fertilisers being better than superphosphate in the year of application, but there is evidence that even this advantage may be lost as residues accumulate.

The experiments provide information on the residual effects of the fertilisers: (a) in the absence of fresh fertiliser; and (b) in the presence of a further application of fertiliser. Fertilisers giving the largest responses in the year of application also tended to produce the largest residual effects of type (a). In one exception, swedes at Trawscoed, rock phosphate residues were more effective than superphosphate residues even though direct application of the mineral form gave smaller responses. Residual effects of type (b) are more important, however, as the residues did not give full yields on their own. At present the experiments provide information only on the residual effects obtained in the presence of small amounts of fertiliser, but it is clear that residual effects of type (b) depend on the type of fertiliser used and can be very much smaller than residual effects of type (a). Indications are that superphosphate gives the largest effects of type (b), but the experiments will have to continue for several more years before the full practical value of these effects can be assessed.

- 12.11. SAWICKI, R. M., ELLIOTT, M., GOWER, J. C. (SNAREY, M. & THAIN, E. M.). (1962.) Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. I. Preparation and relative toxicity of the pure constituents; statistical analysis of the action of mixtures of these components. *J. Sci. Fd Agric.*, **13**, 172–185.

(For summary see above no. 9.18.)

- 12.12. (WILSON, A. R., TWISS, P. T. G.) & LESSELLS, W. J. (1962). Weight-loss and sprouting of bulk-stored maincrop potatoes. *Eur. Potato J.* (In the press.)

Maincrop potatoes stored in bulk under normal commercial conditions in England may be expected to lose by shrinkage on average from 2.5% by the end of January to almost 7% by the end of May in indoor stores, and from 2.5% by the end of February up to 5% by the end of May in clamps. These figures refer only to potatoes remaining sound throughout storage, and do not include any losses from rotting.

Figures from indoor stores suggest that use of forced-draught ventilation in the early winter may decrease losses by shortening the time necessary to achieve the "holding" temperature. Figures are included illustrating the effect of position in clamp or store on weight loss.

- 12.13. YATES, F. (1962). Computers in research—promise and performance. *Comput. J.* (In the press.)

Computers have been extensively used to solve problems involving really heavy computation, such as occur in crystallography, molecular physics and aircraft design, but their use for research statistical calculations has developed relatively slowly. In large part this comes from failure to develop adequate programmes: the solution appears to lie in the construction of specialised autocodes for different classes of statistical problem. Such programmes can be developed only by groups of statistical experts, who can appreciate what is really required, and can advise on their use when written. Specialist computer installations, devoted to some particular subject, have the great advantage that they can carry an adequate team of experts on their own staff. (Presidential Address to the British Computer Society.)

- 12.14. YATES, F. & HEALY, M. J. R. (1962). Electronic computation and data processing for research statistics. *Bull. Inst. int. Statist.*, **4**, 273–279.

This paper discusses the problems of using an electronic computer in a research statistics department. The requirements of such a department differ greatly from those of large-scale data processing; jobs tend to be smaller, a wide variety of different problems arise in an unpredictable manner; and the type of analysis to be applied to a problem can often be decided only when the results of a previous analysis have been inspected. The method being developed at Rothamsted involves the provision of several standard general programmes, each able to handle a whole class of problems. The specification of the requirements of a particular problem can then be greatly simplified. Such programmes must include facilities for extracting relevant data from a large bulk stored on magnetic tape, and should also have editing facilities.

A general programme for survey analysis has been written and used; this is described in detail. Other general programmes for the analysis of experimental designs, time series and other types of data are being considered.

We consider that computing facilities can be most effectively used when different centres specialise to some extent. This thesis raises problems of its own, particularly when a large computer is installed, and we discuss some of these problems in connection with the new computer we hope to install shortly.

Woburn Experimental Station

- 15.1. MANN, H. H. (1961). Classification of the tea plant. *Nature, Lond.*, **191**, 409.

The number of leaf veins has not been a satisfactory criterion for separating varieties of tea.

Dunholme Field Station

GENERAL PAPERS

- 16.1. ADAMS, S. N. (1961). Sugar-beet fertiliser experiments in 1960. *Min. Agric. Sugar Beet Res. & Educ. Comm. Pap.* 626.

- 16.2. ADAMS, S. N. (1961). The manuring of sugar beet. *Chem. & Ind.*, 564-566.
- 16.3. ADAMS, S. N. (1961). The role of sodium in manuring sugar beet in Great Britain. *Rep. 24th Winter Cong. int. Inst. Sugar Beet Res.*, Brussels 1961, 311-316.
- 16.4. ADAMS, S. N. (1961). Fertilisers for beet. Can they be applied before ploughing in the autumn? *Brit. Sug. Beet Rev.*, **29**, 153.
- 16.5. BYFORD, W. J. (1961). Seed dressings: an important development. *Brit. Sug. Beet Rev.*, **29**, 119.
- 16.6. DUNNING, R. A. (1961). Aphids and yellows in 1960 and prospects for 1961. *Brit. Sug. Beet Rev.*, **29**, 117-118.
- 16.7. DUNNING, R. A. (1962). Insecticides and fungicides used to control sugar beet pests and diseases. *Chem. & Ind.*, 155-158.
- 16.8. HULL, R. (1961). A practical man's guide to sugar beet seed. *Fmr & Stk-Breed.*, 31 January, 1961.
- 16.9. HULL, R. (1961). Sugar-beet seed—a product of research developed to suit modern needs. *Centr. Office of Information. In series issued for International Seed Year.*
- 16.10. HULL, R. (1961). The health of the sugar-beet crop in Great Britain. *J. R. agric. Soc.*, **122**, 101-112.
- 16.11. HULL, R. (1961). Yellows in 1961. *Brit. Sug. Beet Rev.*, **30**, 83-84.
- 16.12. HULL, R. (1961). Sugar-beet yellows in Great Britain, 1960. *Plant Path.*, **10**, 149-50.
- 16.13. HULL, R. (1961). Sugar-beet yellows in Europe. *Rep. 1st Joint Mtg int. Inst. Sug. Beet Res. and Amer. Soc. Sug. Beet Tech.*, 1961.

RESEARCH PAPERS

- 16.14. ADAMS, S. N. (1962). The response of sugar beet to fertiliser and the effect of farmyard manure. *J. agric. Sci.*, **58**, 219-226.

Forty-nine 3^3 factorial experiments in 1957-60 tested the response of sugar beet to 0.6, 1.2, 1.8 cwt. N, 0.0, 0.5, 1.0 cwt. P_2O_5 and 0.8, 1.6, 2.4 cwt. K_2O /acre. On forty-one of the sites the experiment was repeated in the presence of 12 tons FYM/acre.

Optimum dressings for sugar beet without FYM were 1.0 cwt. N, 0.5 cwt. P_2O_5 and 1.6 cwt. K_2O /acre. Exceeding the optimum nitrogen dressing decreased sugar yield, although the yield of tops was increased. Many fields required only 0.6 cwt. N/acre, especially those in which the beet followed less than two cereal crops. Response to phosphate and potash did not differ much in different experiments, and the national optimum would have been satisfactory for nearly all fields.

The main value of dung for beet was in the N, P and K it provided. With FYM, optimum dressings for sugar yield were only 0.6 cwt. N, 0.0 cwt. P_2O_5 and 0.8 cwt. K_2O /acre.

The responses on different soil types are discussed.

Soil Survey of England and Wales

17.1. *Soil Map of Bangor*, Sheet 106 (3rd Edn.). Southampton: Ordnance Survey, 1961.

17.2. *Soil Map of Aylesbury*, Sheet 238 (3rd Edn.). Southampton: Ordnance Survey, 1961.

17.3. ASHLEY, G. D. (1961). Grassland and soil structure. *J. Brit. Grassl. Soc.*, **16**, 156–159.

Discussion of some factors and problems in producing a stable crumb structure under British conditions with suggestions for techniques to form a more suitably structured profile.

17.4. BASCOMB, C. L. (1961). A calcimeter for routine use on soil samples. *Chem. & Ind.*, 1826–7.

A simple volumetric apparatus is described that accommodates a larger sample (< 1 gm. CaCO₃) than the generally used Collin's calcimeter without loss of accuracy, thus making subsampling less difficult.

17.5. BRIDGES, E. M. (1961). Aspect and time in soil formation. *Agriculture, Lond.*, **68**, 258–263.

For soils developing on reclaimed overburden left in "hill and dale" relief, aspect is at least as important as time, and soil forms very slowly on north-facing slopes. Complete larch canopy gives moist soil conditions and lowers pH values; with less canopy the values are higher on this very mixed parent material.

17.6. CRAMPTON, C. B. (1961). An interpretation of the micro-mineralogy of certain Glamorgan soils: the influence of ice and wind. *J. Soil Sci.*, **12**, 158–171.

Criteria for recognising the presence of wind-blown materials are discussed. Some soil series are shown to be formed essentially on local ice-produced drift, others to be derived mainly from the underlying rock with additional ice- and wind-borne material; yet others are influenced by the underlying rock and wind-blown material only.

17.7. CROMPTON, A. (1961). A brief account of the soils of Yorkshire (with map). *J. Yorks. Grassl. Soc.* No. 3, 27–35.

17.8. HIRST, J. M., LE RICHE, H. H. & BASCOMB, C. L. (1961). Copper accumulation in the soils of apple orchards near Wisbech. *Plant Path.*, **10**, 105–108.

(For summary see above no. 7.20.)

17.9. MACKNEY, D. (1961). A study of podzolisation under oakwood and heath in Central England. *J. Soil Sci.*, **12**, 23–40.

The following sequence of processes probably occurs while a slightly podzolised sandy brown earth develops into a humus-iron podzol: translocation of clay, association of iron with organic matter and slight eluviation of iron, strong iron eluviation, eluviation of organic matter. Pollen analysis helps to establish that podzolisation occurs under oakwood where edaphic environments are favourable.

17.10. THOMASSON, A. J. (1961). Some aspects of the drift deposits and geomorphology of south-east Hertfordshire. *Proc. geol. Ass., Lond.*, **72**, 287–302.

Further data on the lithology and mineralogical composition of the deposits are presented and their chronology and derivation are discussed. The asymmetric valleys in this and neighbouring areas are discussed.