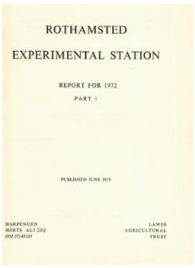
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ROTHAMSTED RESEARCH

Report for 1972 - Part 1

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Rothamsted Research

Rothamsted Research (1973) *Abstracts of Rothamsted Papers ;* Report For 1972 - Part 1, pp 323 - 370 **- DOI: https://doi.org/10.23637/ERADOC-1-127**

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Physics Department

Thesis

1.1 Legg, B. J. (1971) Turbulent transport in a crop canopy. Ph.D. Thesis, University of London.

General Paper

1.2 Penman, H. L. (1972) Weather 1971. *Transactions of Hertfordshire Natural History Society*, **27**, 209.

Paper in Rothamsted Report, Part 2

1.3 French, B. K., Long, I. F. & Penman, H. L. (1973) Water use by farm crops.
I Test of the neutron meter on barley, beans and sugar beet, 1970.
II Spring wheat, barley, potatoes (1969); potatoes beans, kale (1968).
III Bare soil, short turf and crops in rotation, 1962 to 1967, 1971.
Rothamsted Experimental Station. Report for 1972, Part 2, 5–42, 43–61, 62–85.

Summary of Part III. Trusting the meter, all useful results from 1962 onwards are set out, including some measurements (1962, 1963) confirming that evaporation from bare soil is greater in a wetter summer, plus an extended set of observations (1971) that showed actual evaporation to be the same as potential evaporation for a short turf surface (i.e. $\kappa = E/E_T \cong 1{\cdot}0$). Except for potatoes and beans, monitoring to 90 cm was not enough, and at times the greater depth (to 150 cm) was barely adequate for cereals, sugar beet and kale: these crops show drying to at least 120 cm depth and often to 150 cm. On several occasions this deep drying persisted, without any obvious check, in periods when the upper soil layers showed a gain in water because of excess rain. In amount, the maximum net drying varied as the depth of action. For potatoes and beans it was about 30 to 50 mm before there was a check to rate of transpiration: for the other crops there was no check until 100 mm or more had been used. Usually, but not always, irrigated plots used more water than the controls (never less), the difference, ΔE being, in general $\ll I$, and this is the extra amount transferred to the atmosphere. The remainder, $I - \Delta E$, is a gain in profile, held or already moved down as drainage, at the end of the season. Values of κ were near 1·15 for hay grasses, winter wheat, spring barley, beans and potatoes, but spring wheat, sugar beet and kale gave values close to 1·3—surprisingly large. Nearly every year there was evidence of rain or irrigation water penetrating the soil profile without bringing any wetted layer to field capacity first, with possible consequences for movement of machinery and implements over the soil. Maintained wetting seemed to restore a field capacity, in that the water content 0 to 150 cm in February 1972 was the same as that measured at the wettest state in mid-June 1971, but it remains doubtful whether the concept is valid during the growing season, and some of the measured drying may be drainage.

Research Papers

1.4 Currie, J. A. (1973) The seed-soil system. In: *Seed Ecology*. (*Proceedings of the 19th Easter School in Agricultural Science, University of Nottingham, 1972*). Chapter 25. London: Butterworths.

Of the four physical factors, water, aeration, temperature and light, known to influence the germination of seeds, water and aeration are the two most likely to be affected by soil properties. The soil particles form a porous matrix within which water and air are not only contained, but, of greater importance, through which water and components of the soil air must move to satisfy the demands of the seed. Both texture and structure affect the pore size distribution in soil. This in turn determines the water content, the relationship between water content and the potential at which water is held against withdrawal, and the relationship between water content and hydraulic conductivity. Air is restricted to that part of the pore space not already filled by water. Gaseous exchange between the seed and the soil is affected by the composition of the air at the

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seed surface. This is determined in part by the rate of respiration by competitive soil micro-organisms, and in part by the rate at which the gases involved may diffuse, at best, through any continuous air-filled channels, or, at worst, in solution through the soil water. Except in warm waterlogged soils, there is probably little risk of inadequate aeration for germination

Seed size and shape are important. They determine the amount of water required, thus the zone of water depletion within the soil around the seed, and hence the time scale of the inhibition process. The size of the seed and roughness of the seed surface affect the area of contact between soil and seed and therefore the transmission of water to the seed.

In the field where the seed is in the surface soil layer, it does not experience a constant daily temperature. Cyclic temperature changes, caused by solar radiation, may mean that the seed experiences more favourable conditions for germination than might be indicated by a thermometer alone.

1.5 (HACKETT, C.) & ROSE, D. A. (1972) A model of the extension and branching of a seminal root of barley, and its use in studying relations between root dimensions. I. The model. *Australian Journal of Biological Sciences* **25**, 669–679.

Relations between the total number, length, surface area, and volume of graminaceous root members tend to remain roughly constant during vegetative growth. The present paper describes a model that takes advantage of the fact that the extension and branching of cereal root members grown in homogeneous media proceed at approximately constant rates for lengthy periods. The overall dimensions of roots can therefore be described by formulae containing time and a limited number of properties of each type of root member. The validity of the model is checked against actual measurements. Other possible roles for the model are suggested.

1.6 (HACKETT, C.) & ROSE, D. A. (1972) A model of the extension and branching of a seminal root of barley, and its use in studying relations between root dimensions. II. Results and inferences from manipulation of the model. *Australian Journal of Biological Sciences* **25**, 681–690.

The model was used to investigate why the average length ($\bar{l}$) of cereal root members remains roughly constant. Taking as a standard the model root which agreed with actual roots from an experiment, the nine variables in the model were altered singly to see which had greatest influence on $\bar{l}$.

The constancy of $\bar{l}$ was due primarily to a limit on the rate at which each class of root member can extend, probably determined by a property associated with the diameter of the root member, and with the timing of the onset of each order of branching. This timing was related to that at which the parent members, as a population, began to increase roughly linearly in volume. A tentative explanation is given.

A full explanation of the phenomenon will need more information about certain aspects of root development.

1.7 LAKE, J. V. (1972) Preparation of mixtures for the calibration of gas analysers. *Journal of Experimental Botany* **23**, 1096–1098.

Differential gas analysers for use in photosynthetic experiments can be calibrated with the same accuracy as that specified for the single gas mixture that is required. With the use of only one gas mixing pump, the composition of a mixture can be specified to better than $\pm 1\%$, compared with $\pm 5\%$ usually offered by commercial gas suppliers.

1.8 SZEICZ, G. (TAMAKI, S. & VAN BAVEL, C. H. M.) (1971) Environment, water use and dry matter production in sorghum. *Report from Texas Agricultural Experiment Station*, December 1971, 80 pp.

Relevant soil, plant and atmospheric parameters were measured throughout a growing season and processed by computor. Results show that simple plant measurements can be exploited to estimate actual water use by crops.

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Chemistry Department

Thesis

2.1 Addiscott, T. M. (1972) The effect of potassium nutrition on the uptake and distribution of nutrient ions in developing potato plants. Ph.D. Thesis, University of London.

General Papers

2.2 Addiscott, T. M. (1971) Potassium : calcium exchange in soils of the Broadbalk experiment at Rothamsted. *Potash Review*, Subject 4, 49th Suite, 9 pp. (Reprinted from *Journal of Agricultural Science* (*Cambridge*) (1970) **75**, 451–457.)

2.3 Benzian, B., Freeman, S. C. R. & Patterson, H. D. (1972) Comparisons of crop rotations, and of fertilisers with composts, in fifteen-year experiments with Sitka spruce. *Report on Forest Research* (*London*) *1972*, pp. 139–142.

2.4 Islam, A. & Bolton, J. (1971) The effect of soil pH on potassium intensity and release of non-exchangeable potassium to ryegrass. *Potash Review*, Subject 4, 48th Suite, 8 pp. (Reprinted from *Journal of Agricultural Science* (*Cambridge*) (1970) **75**, 571–576.)

2.5 Nowakowski, T. Z. (1973) Effects of potassium and sodium on the contents of soluble carbohydrates and nitrogenous compounds in grass. *Proceedings of the 8th Colloquium of the International Potash Institute 1971*, 45–49.

2.6 Rawson, R. A. G. (1973) A 'total-consumption' 'Laminar-flow' nebulizer and burner system for flame spectroscopy. *Proceedings of the 3rd International Congress on Atomic Absorption and Fluorescence Spectroscopy, September 1971*, **1**, 165–174.

2.7 Widdowson, F. V. (1972) Some problems involved in doing experiments with liquid fertilisers. *Proceedings of the 3rd International Conference on Mechanisation of Field Experiments*. Brno, Czechoslovakia. 10–15 July 1972, 2–7.

Papers in Rothamsted Report, Part 2

2.8 Bolton, J. (1973) Effects of potassium, magnesium and sodium fertilisers and lime on the yield and composition of crops in a 10-year experiment at Rothamsted. *Rothamsted Experimental Station. Report for 1972*, Part 2, 102–110.

Potassium fertiliser increased yields of ryegrass, clover, potatoes, kale and barley. Magnesium increased yields only of barley; sodium had no effect. Liming to a soil pH of 6·5 instead of 5·4 (from an initial pH of 4·6) increased yields of barley and kale. Crop and soil analyses are presented and discussed.

2.9 Johnston, A. E. (1973) The effects of ley and arable cropping systems on the amounts of soil organic matter in the Rothamsted and Woburn Ley Arable experiments. *Rothamsted Experimental Station. Report for 1972*, Part 2, 131–159.

Changes in organic carbon in experiments lasting more than 30 years at Woburn and 20 years at Rothamsted are given. The treatments tested included three-year leys of lucerne and cut and grazed grass, alternated with three years of arable crops, and longer periods in both grass and arable crops. The effects of the treatments on soil organic carbon are compared with those from continuous arable cropping.

2.10 Slope, D. B., Etheridge, J. & Williams, R. J. B. (1973) Grain yield and the incidence of take-all and eyepsot in winter wheat grown in different crop sequences at Saxmundham. *Rothamsted Experimental Station. Report for 1972*, Part 2, 160–167.

(For summary see No. 7.19.)

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2.11 WIDDOWSON, F. V. & PENNY, A. (1973) Yields and N, P and K contents of the crops grown in the Rothamsted Reference experiment, 1956–70. *Rothamsted Experimental Station. Report for 1972*, Part 2, 111–130.

The effects of N, P and K fertilisers and of FYM on the yield of five arable crops and of permanent grass are given and discussed. The amounts of N, P and K recovered by the crops from fertilisers, from FYM, and from the soil are also given and from these a balance sheet for N, P and K constructed. The changing effects of the N, P and K fertilisers and of soil P and K status over the 15 years are shown and discussed.

2.12 WILLIAMS, R. J. B. (1973) Changes in the nutrient reserves of the Rothamsted and Woburn Reference experiments. *Rothamsted Experimental Station. Report for 1972*, Part 2, 86–101.

Changes in the nutrient reserves of the Rothamsted Reference experiment on a clay loam over Clay-with-flints (1956–70) and the Woburn Reference experiment on a light sandy loam over Lower Greensand (1960–69) are related to the fertilisers and manures applied and nutrients removed by five crops in a rotation and by permanent grass. The results of the experiments, on contrasted soils with different histories, are compared.

RESEARCH PAPERS

2.13 ASHWORTH, J (1973) Reactions of ammonia with soil. I. Adsorption isotherms and calorimetric heats of adsorption of ammonia gas on homo-ionic soil. *Journal of Soil Science* **24**, 104–116.

Heats of adsorption and adsorption isotherms of ammonia gas were measured at 300 K (27°C) on outgassed soil saturated with Na^+, K^+, NH_4^+, Ca^{2+}, or Mg^{2+} ions. The Ca and Mg soils adsorbed apparently one more NH_3 molecule per exchangeable ion than the Na and K soils, mostly in the relative pressure range 0 to 0·005, but not much more than the NH_4 soil. The initial heat of adsorption was *c.* 75 kJ mol^{-1} on the Ca and Mg soils and *c.* 60 kJ mol^{-1} on the other soils. The results suggest that most NH_3 is sorbed on these soils through reactions not involving exchangeable cations.

2.14 BENZIAN, B. (1972) Cumulative dressings of potassium metaphosphate and soluble PK-fertilisers for seedlings and transplants of *Picea sitchensis* in two English nurseries. *Plant and Soil* **36**, 243–245.

Cumulative dressings of potassium metaphosphate tested on seedlings and transplants of *Picea sitchensis* gave promising results from 1964 to 1966 at two nurseries—a sandy podsol and a sandy loam with better nutrient retention. The four experiments, which also included superphosphate alone, KCl/superphosphate, with and without topdressings of KNO_3, and potassium dihydrogen phosphate, were continued until 1969. On the podsol, potassium metaphosphate maintained its superiority for seedlings and also left larger residues in the surface soil. It had no special merit on the sandy loam or for transplants on either soil.

2.15 BENZIAN, B., FREEMAN, S. C. R. & PATTERSON, H. D. (1972) Comparison of crop rotations, and of fertiliser with compost, in long-term experiments with Sitka spruce (*Picea sitchensis*) in two English nurseries. *Forestry* **45**, 145–176.

Groups of related experiments, of more than 300 plots, with seedlings and transplants of *Picea sitchensis*, tested inorganic fertiliser and bracken-hopwaste compost, and compared continuous conifer cropping with a rotation in which one conifer crop in three was replaced by fallow or a green manure crop. The experiments, lasting 15 years, were done in a nursery on moderately acid agricultural land at Kennington and in a heathland nursery on an acid sandy podsol at Wareham.

At Kennington, seedlings given fertiliser grew better throughout than those given compost, with no additional benefit when both were given, despite considerable increases in soil organic matter and nutrients on compost-treated plots. On plots with fertiliser, growth was maintained

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during the experimental period. At Wareham, fertiliser lost its initial advantage; neither of the manurial treatments supplied adequate amounts of major nutrients but fertiliser and compost together was better than either alone.

With transplants, at both nurseries, fertiliser was slightly more effective during the early years, but compost later.

Interrupting continuous conifer cropping by fallow or green crops had no advantage at either nursery.

2.16 BOLTON, J. (1972) Changes in magnesium and calcium in soils of the Broadbalk wheat experiment at Rothamsted from 1865 to 1966. *Journal of Agricultural Science* (*Cambridge*) **79**, 217–223.

Chalk in the 0–9 in. topsoil of Broadbalk has declined from nearly 5% in 1865 to less than 1% in some plots in 1966, and fastest in plots given ammonium sulphate. Losses were equivalent to 5–8 cwt limestone/acre annually. The paper relates these rates to estimated anion losses, especially bicarbonate, from the plots.

N-ammonium acetate dissolved Ca and Mg from chalk particles in the soils. After correcting for this, exchangeable magnesium had increased during the first 50 years but decreased since 1914 in the FYM plot. In plots given none or 10 lb/acre of magnesium in fertiliser annually, exchangeable magnesium had changed little since 1865. This suggests that equilibrium was soon established between additions and losses of Mg in all except the FYM plots. Estimates of annual additions and losses of Mg from each plot show that an equilibrium is feasible without large gains from non-exchangeable soil resources. A method of calculating losses of Mg in the drainage using activity ratios and annual calcium losses was developed.

2.17 BROMFIELD, A. R. (1972) Absorption of atmospheric sulphur by mustard (*Sinapis alba*) grown in a glasshouse. *Journal of Agricultural Science* (*Cambridge*) **78**, 343–344.

Atmospheric sulphur absorbed by the crop amounted to 49·2% of the total plant sulphur at harvest. A vertical deposition velocity constant of 1·0 cm/s was calculated from the increased uptake of atmospheric S per pot between 24 and 44 days.

2.18 BROMFIELD, A. R. (1972) Sulphur in Northern Nigerian soils. 1. The effects of cultivation and fertilisers on total S and sulphate patterns in soil profiles. *Journal of Agricultural Science* (*Cambridge*) **78**, 465–470.

Organic-S and sulphate-S were measured in the Northern Guinea savannah zone down soil profiles under undisturbed natural vegetation, and in land cleared and cropped, with and without fertilisers and farmyard manure. The main soil type was a drained, red to red-brown, sandy clay to clay loam (pH 4·1–5·6 in 0·01*M* $CaCl_2$), which strongly sorbed sulphate.

Organic-S was most in the surface layers and decreased with depth. Root remains from the natural fallow vegetation, present up to nine years after clearance, strongly influenced the distribution of organic-S. The roots disappeared after 19 years, when distribution of organic-S mainly reflected crop-root distribution; amounts of organic-S were related to crop yields. FYM was less effective in maintaining organic-S than fertilisers containing P and N.

Profiles under natural vegetation contained little sulphate-S but it accumulated in the subsoil after clearance when S was not removed. The sulphate pattern of profiles under unfertilised crops resembled that under natural vegetation. All fertilised sites had a well-defined sulphate sorbtion pattern, the deepest maximum was at 50 cm on a plot where more than 800 kg S/ha had been applied in nineteen annual amounts. Sulphate-S ranged from <1 ppm, in the deepest samples to 52 ppm at the absorption maximum.

Almost all the sulphur applied was in the profiles or removed in harvested crops, showing that losses from erosion and leaching were small.

2.19 GASSER, J. K. R., BLAKEMORE, M. & FLINT, R.C. (1972) Experiments on the use of anhydrous ammonia for grass. *Journal of Agricultural Science* (*Cambridge*) **78**, 193–201.

A hand injector was used to inject ammonia into soils in pots in which ryegrass was subsequently grown and under grass in the field; the spacing was varied.

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Injecting ammonia or applying ammonium nitrate at one point or three points in the middle of a clay-loam and a sandy-loam soil in pots did not affect the growth of grass or its uptake of N. Grass with ammonium nitrate grew slightly better than with ammonia on the sandy loam and slightly worse on the clay loam.

Best yields of dry matter and most uptake of N were obtained from grass swards having ammonia injected in lines 23 and 30 cm apart and the injection points from one-quarter to one-half of the distance between rows. Increasing the distance between lines from 30 to 45 cm diminished total yield and uptake because the strip 15·2 to 22·8 cm from the line of injection grew less than grass nearer to the line of injection.

With grass grown in rows 12·1 cm apart, yields were greatest with the lines of injection perpendicular to the rows of grass and least with the ammonia injected along and into the rows. The yield of dry matter of the row with ammonia injected into it was usually less than of the adjacent row and the percentage N in the grass was usually more, so that the weight of N in the grass sometimes increased and sometimes decreased with distance from the line of injection depending on the relative changes in yield of dry matter and of percentage N.

2.20 GASSER, J. K. R. & the late THORBURN, M. A. P. (1972) The growth, composition and nutrient uptake of spring wheat. Effects of fertiliser-N, irrigation and CCC on dry matter and N, P, K, Ca, Mg and Na. *Journal of Agricultural Science* (*Cambridge*) **78**, 393–404.

Kloka spring wheat grown on a sandy-loam soil was given 50, 100, 151 or 201 kg N/ha as fertiliser, was irrigated during drought or not irrigated, and was sprayed with CCC (2-chloroethyltrimethylammonium chloride) or not sprayed. Samples, taken approximately weekly from brairding to heading and less frequently to maturity measured the production of dry matter. The dried samples were analysed for percentage N, P, K, Ca, Mg and Na and the uptakes of these were calculated to measure the effects of treatments on the composition of the crop and the weights of nutrients it contained.

Increasing amounts of fertiliser-N up to 151 kg N/ha increased the maximum weight of straw without irrigation and up to 201 kg N/ha with irrigation; similarly, maximum weights of ears were with 100 kg N/ha without irrigation and 151 kg N/ha with irrigation. The maximum weight of straw was at flowering and of ears at maturity. Irrigation increased yields of straw and ears, more with the two larger than with the two smaller amounts of fertiliser-N. Spraying with CCC decreased the yield of straw, and did not affect the yield of ears.

Increasing amounts of fertiliser-N increased percentage nutrients in the green crop and in the straw, and of N, P and Mg in the ears. Effects of irrigation and spraying with CCC on composition differed between nutrients and between ears and straw, sometimes increasing, sometimes decreasing, and sometimes having no effect, on percentage in dry matter.

Increasing fertiliser-N increased the maximum weight of N, K, Ca and Na in the crop. P and Mg increased with up to 151 kg N/ha, but was no more with 201 kg N/ha. Maximum weight of N, P, Mg and Na was found at or near maturity, of K at heading and of Ca at flowering.

2.21 (JOHNSTON, H. W.) BRIGGS, G. G. & (ALEXANDER, M.) (1972) Metabolism of 3-chlorobenzoic acid by a pseudomonad. *Soil Biology & Biochemistry* **4**, 187–190.

A *Pseudomonas* species which utilised 3-chlorobenzoic acid as a carbon source converted this compound to 3-hydroxybenzoic and 2,5-dihydroxybenzoic acids. The products were identified by thin-layer and gas chromatography and infrared spectrophotometry. The bacterium was unable to utilise nitro- or other chloro-substituted benzoic acids as carbon sources for growth.

2.22 LE MARE, P. H. (1972) A long term experiment on soil fertility and cotton yield in Tanzania. *Experimental Agriculture* **8**, 299–310.

Compost or ammonium sulphate improved and maintained cotton yield for six years but both, together with triple superphosphate, were needed to maintain it for nine years, after which yield declined and lime was necessary. Compost supplied necessary but insufficient phosphorus, potassium, calcium and nitrogen. Manganese toxicity was severe when potassium chloride was used on very acid soil. At suitable soil pH and with adequate phosphorus and cations, response to nitrogen was large, but for it to be most effective, calcium seemed necessary to maintain the

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cation : anion ratio. Without lime, yields declined with heavy rain; with it they were largest in the wettest seasons.

2.23 NOWAKOWSKI, T. Z. & BYERS, M. (1972) Effects of nitrogen and potassium fertilisers on contents of carbohydrates and free amino acids in Italian ryegrass. II. Changes in the composition of the non-protein nitrogen fraction and the distribution of individual amino acids. *Journal of the Science of Food and Agriculture* **23**, 1313–1333.

Italian ryegrass (*Lolium multiflorum*) S22, grown in a greenhouse in K-deficient soil in pots, was given 40, 80 and 160 mg of N/kg of soil (as ammonium nitrate) and 0, 60, 120 and 240 mg of K/kg of soil (as potassium chloride). In grass grown without added K, increasing N fertiliser increased the concentrations of total N, non-protein-N, ammonium-N, nitrate-N, free amino acids, amides and amines. With adequate K fertiliser all these N fractions decreased.

The percentage distribution of N in the free amino-acid pool varied with the amount of N and K given. Without K fertiliser, increasing N had no consistent effect on most amino acids and amides, although it decreased the percentages of alanine and ethanolamine. Increasing K had relatively little effect on the percentage distribution in grass given the two smaller amounts of N. However, in the grass given the largest amount of N, it increased the percentage of most amino acids, especially alanine and 4-amino-*n*-butyric acid, and decreased glutamine and asparagine. β-Alanine was found only in K-deficient plants.

The effect of K in relation to N metabolism and the nutritive value of herbage is briefly discussed.

2.24 ONIANI, O. G., CHATER, M. & MATTINGLY, G. E. G. (1973) Some effects of fertilisers and farmyard manure on the organic phosphorus in soils. *Journal of Soil Science* **24**, 1–9.

The amounts of P applied cumulatively to a neutral arable soil (pH 7·1–7·4 in 0·01*M* $CaCl_2$) at Rothamsted, as farmyard manure, alone or with superphosphate, which were converted to organic P in 100 years ranged from 18 to 44 μg P/g of soil (0–23 cm). Superphosphate alone (3300 kg P/ha) slightly lessened the total organic P in the soil. Neither farmyard manure nor superphosphate significantly changed the amounts (38 to 42 μg P/g) of inositol penta- and hexaphosphate in these soils. In the surface layers (0–7·5 cm) of soils from permanent grassland at Rothamsted, superphosphate (3370 kg P/ha) increased organic P by 134 μg P/g at pH 4·5 and 19 μg P/g at pH 6·5, about 6 and 1% respectively of the P remaining from superphosphate applied cumulatively since 1858. In the sub-surface layers (7·5–23 cm) superphosphate increased organic P by 93 μg P/g at pH 4·5 and 62 μg P/g at pH 6·2, about 18 and 10% respectively of the P remaining from superphosphate. The sum of inositol penta- and hexaphosphates accounted for 32% at pH 4·5 and 21% at pH 6·5 of the increases in organic P in the surface layers and 45% and 26% in the sub-surface layers at pH 4·5 and 6·5 respectively.

Superphosphate (1260–2100 kg P/ha) applied intermittently or cumulatively increased total organic P by 19 to 52 μg P/g and inositol penta- and hexaphosphates by 13 to 17 μg P/g in acid tea soils (pH 3·2–3·4) from Georgia, USSR. Rock phosphate (510–1020 kg P/ha) applied cumulatively had no effect on either the total organic P or the inositol P in acid tea soils (pH 3·6–3·7) from Ceylon.

2.25 (SINGH, M. M., PUSHPARAJAH, E., SOONG, N. K.) & TALIBUDEEN, O. (1972) Radiotracer studies on phosphorus uptake by *Hevea brasiliensis* from Malayan soils for determining 'active' root distribution. *Proceedings of a Symposium on 'Isotopes and radiation in soil-plant relationships including Forestry'*. 13–17 December 1971, IAEA, Vienna. 465–479.

Techniques for the measurement of phosphorus uptake by mature trees of *Hevea brasiliensis* from different soils and soil zones using ^{32}P are examined. Although leaf and latex assay give similar results, latex assay is less tedious and more reliable because the leaf assay is affected by variations caused by age of leaf and position on the tree. Uptake of tracer increases rapidly after two weeks. Leaf radioactivity tends to decrease after six weeks but that of latex continues to

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increase. The best time of assay is 4–6 weeks after tracer application. Although soil heterogeneity and tree-to-tree variability is considerable, significant differences in patterns of nutrient uptake from different soils and soil zones have been measured.

2.26 TALIBUDEEN, O. (1972) Using radiotracers in soil chemistry research. *Proceedings of a Symposium on 'Isotopes and radiation in soil-plant relationships including Forestry'*. 13–17 December 1971, IAEA, Vienna. 133–143.

Some models described summarise the more important chemical transformations in the soil–plant system and show how radio-isotopes have helped recently to give a better and more precise understanding of these processes.

2.27 TALIBUDEEN, O. (1972) Exchange of potassium in soils in relation to other cations. *Proceedings of the 9th Colloquium of the International Potash Institute 1972*, 75–90.

Categories of soil potassium and criteria to define their properties and inter-relations, referring specially to the exchange of potassium with other cations, are described. Extensive soil properties, such as clay and fine clay content and mineralogical composition, are not absolute guides to K exchange and release to crops.

The term '*non-exchangeable* potassium' is a misnomer, and its value in soils to crops is related to the dominant counter-cation in the soil and the characteristics of the crop. Attempts to find a single and simple method of defining the ability and capacity of the soil to release so-called 'non-exchangeable' K to crops seem misguided. Differences between residual K, accumulated in soil from K fertilisers, and K that is part of the original mineral matrix, have not been precisely demonstrated. Criteria are suggested that might be used to do so.

2.28 TALIBUDEEN, O. & WEIR, A. H. (1972) Potassium reserves in a 'Harwell' series soil. *Journal of Soil Science* **23**, 456–474.

A sample of Harwell soil containing 36% fine clay (<0·3 μm) and 14% coarse clay plus fine silt (0·3–5 μm) was separated into fractions, and the K-supplying power of soil and fractions measured by cropping with ryegrass, exchange with Ca resin and double-label isotopic exchange with ^{42}K and ^{45}Ca ions.

Mineralogical examination of the fractions coupled with the cropping experiments showed that the K-supplying power of the soil to ryegrass can be explained by the presence of a zeolite, clinoptilolite-heulandite, in addition to the clay minerals, mica, and interstratified illitic smectite, commonly found in a glauconitic clay-rich soil. The 0·3–5 μm fraction, containing much zeolite, has an exchange diffusion coefficient for K ions to Ca resin of $1{\cdot}8 \times 10^{-16}$ cm^2 sec^{-1} compared with a value of $5{\cdot}7 \times 10^{-20}$ for the <0·3 μm fractions in which interstratified illitic smectite is the dominant mineral. Isotopic exchange shows that all Ca ions in fractions <50 μm are isotopically exchangeable. In fractions coarser than 20 μm, some of the K ions in felspar and mica were not exchangeable within the duration of the experiments.

2.29 WIDDOWSON, F. V., PENNY, A. & FLINT, R. C. (1972) Results from an experiment comparing aqueous ammonia with 'Nitro-Chalk' for grazed grass. *Journal of Agricultural Science* (*Cambridge*) **79**, 341–348.

Aqueous ammonia supplying 125, 250, 375 or 500 kg N/ha was injected in spring (in bands 10–13 cm deep and 30 cm apart) into old permanent pasture stocked with cattle. Yields from it were compared with those from 'Nitro-Chalk' supplying the same total quantities of N, but broadcast in six equal amounts during the growing season. The tests were made first in 1969 and repeated on the same plots in 1970 and in 1971.

Yields of herbage were measured by placing cages (0·9144 m square) on different parts of each plot during six grazing periods of an eight-month growing season (1 March to 30 October). The cages protected this grass from cattle, otherwise grazing unrestrictedly.

Aqueous ammonia produced slightly more dry matter during the first three periods (1 March to 30 June) and 'Nitro-Chalk' slightly more during the last three (1 July to 30 October). Total yields from the two sorts of N were similar.

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Percentage N in dry herbage was larger with aqueous ammonia than with 'Nitro-Chalk' during the first three periods, the same with both fertilisers during the fourth, but larger with 'Nitro-Chalk' during the fifth and sixth periods.

Without N the pasture contained 36% of wild white clover during the first three grazing periods and 28% during the last three. Giving 125 kg N/ha of either fertiliser decreased clover by more than half, and with more N the pasture contained less than 5% of clover.

2.30 WIDDOWSON, F. V., PENNY, A. & FLINT, R. C. (1972) Results from barley experiments comparing aqueous ammonia and aqueous urea with ammonium nitrate, and also liquid with granular NPK fertilisers. *Journal of Agricultural Science* (*Cambridge*) **79**, 349–361.

In 14 experiments made from 1968 to 1970 yields of, percentages of N in and amounts of N removed by the grain were compared: (1) when N was injected, either as aqueous ammonia (with or without a combine-drilled 'starter' dose of N) or as aqueous urea, or when broadcast as ammonium nitrate ('Nitro-Chalk 21') and: (2) when comparable liquid (14–6–8) and granular (20–10–10) NPK compound fertilisers were applied, either over the seedbed (sprayed or broadcast), or combine-drilled. All were applied to give 63 or 126 kg N/ha.

Barley yields were increased significantly more by combine-drilled than by broadcast PK (0–20–20) fertiliser, especially when only 32 kg P_2O_5 and K_2O/ha was given. N was better combine-drilled than broadcast when 63 kg/ha was given, but not with 126 kg/ha. Soil analyses suggested a limiting value for P.

Yields and N recoveries were largest when one-fifth of the N was combine-drilled as (6–15–15) and the remainder injected as aqueous ammonia in bands 30 cm apart and 12 cm deep. Injecting all the N, either as aqueous ammonia or as urea, gave yields a little smaller than this, but still larger than from broadcasting ammonium nitrate.

The liquid NPK fertiliser gave smaller yields than the granular one in the two dry springs (1968 and 1969), but similar yields in the cool wet one (1970), both when applied over the seedbed and when combine-drilled. The smaller yields with the liquid fertiliser were associated with a severe check and loss of plant when it was combine-drilled (presumably caused by urea) and poorer growth after it was sprayed (presumably through loss of N to the air and greater dispersal of P in the soil). The single amount of each fertiliser increased yields more when combine-drilled than when broadcast, but not the double amount, which, especially as liquid, was safer when surface-applied. Effects of site and season upon mean yields were large.

2.31 WIDDOWSON, F. V. (1973) Results from experiments with barley and wheat measuring the effects of paths on yield. *Experimental Husbandry* No. 23, 16–20.

Paths (14, 21 or 28 in. wide) around plots nominally 9 ft 4 in. wide and 50 ft long increased yields of both wheat and barley, or conversely the effective area harvested, by up to 12%. This effect was eliminated by adding half the width of each longitudinal path (to a maximum width of 21 in.) to the internal plot width of 8 ft 9 in. (first to last row measurement), and ignoring effects on plot length.

As an approximation we suggest adding 80% of half the width of each longitudinal and each transverse path (to a maximum width of 21 in.) to the internal plot dimensions (first to last row × row length).

Pedology Department

THESES

3.1 BLAZA, A J. (1972) The secondary nutrient status of Malawi soils. M.Phil. Thesis, University of Nottingham.

3.2 POWLSON, D. S. (1972) The effects of fumigants on soil respiration and mineralisation of nitrogen. Ph.D. Thesis, University of Reading.

GENERAL PAPERS

3.3 CATT, J. A. & MADGETT, P. A. (1972) Dimlington. *Quaternary Research Association Field Guide, East Yorkshire and North Lincolnshire* (Ed. L. F. Penny), 7–10.

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3.4 CATT, J. A. & MADGETT, P. A. (1972) Sewerby. *Quaternary Research Association Field Guide, East Yorkshire and North Lincolnshire* (Ed. L. F. Penny), 16–17.

3.5 MADGETT, P. A. & CATT, J. A. (1972) Soils. *Quaternary Research Association Field Guide, East Yorkshire and North Lincolnshire* (Ed. L. F. Penny), 22–24.

RESEARCH PAPERS

3.6 BROWN, G., EDWARDS, B. S., ORMEROD, E. C. & WEIR, A. H. (1972) A simple diffractometer heating stage. *Clay Minerals* **9**, 407–414.

The construction of a heating stage for examining oriented clay specimens in a Philips diffractometer is described. The stage, which is simple and cheap to make, is interchangeable with standard specimen holders, operates over the range 20° to 265°C and does not require the diffractometer to be specially modified. The maximum temperature attained at the surface of the specimen collapses freely expanding Mg-saturated vermiculite and prevents re-expansion of layer silicate minerals once they have been collapsed.

3.7 MADGETT, P. A. & EDWARDS, B. S. (1972) A jig to cut glass slips for use with the heating stage. Appendix to paper 3.6.

3.8 RAYNER, J. H. & BROWN, G. (1973) The crystal structure of talc. *Clays and Clay Minerals* **21**, 103–114.

The crystal structure of a sample of talc from Harford County, Maryland, has been determined from X-ray diffraction photographs by least squares refinement. A triclinic cell with $a = 5{\cdot}293$, $b = 9{\cdot}179$, $c = 9{\cdot}496$ Å, $\alpha = 90{\cdot}57°$, $\beta = 98{\cdot}91°$, $\gamma = 90{\cdot}03°$, space group $C\bar{1}$ is adopted. The layers of the structure have almost monoclinic symmetry but the nearly hexagonal rings of oxygen atoms on the surfaces of the layers, formed by the bases of the silica tetrahedra, are not held in register by interlayer cations, as they are in micas, but are partly displaced so that the stack of layers forms a triclinic crystal. The hexagons of surface oxygen atoms are distorted by a 3·4° twist of the tetrahedra, so that the b axis is 0·2% shorter than in a structure with regular hexagons, and the twist brings the oxygen ions a little closer to the magnesium ions.

3.9 TALIBUDEEN, O. & WEIR, A. H. (1972) Potassium reserves in a 'Harwell' series soil. *Journal of Soil Science* **23**, 456–474.
(For summary see No. 2.28.)

3.10 WILLIAMS, C. & (THORNTON, I.) (1972) The effect of soil additives on the uptake of molybdenum and selenium from soils from different environments. *Plant & Soil* **36**, 395–406.

Perennial ryegrass and red clover were grown in the glasshouse on six soils from different geochemical environments in Co. Limerick, Somerset, and Staffordshire, to study the influence of various soil additives on the uptake of molybdenum and selenium by the plants.

Ammonium sulphate most successfully and consistently depressed the uptake of molybdenum by perennial ryegrass and red clover. It seems that the decrease in the molybdenum content of the herbage is caused largely by the ammonium ion. Uptake may also be decreased by dilution due to the greater amount of dry matter produced, by acidification of the soil and by the effect of the sulphate ion. The importance of these contributing factors differs from one environment to another.

Ammonium sulphate and elemental sulphur markedly decreased the selenium content of herbage, the ammonium salt giving most persistent effect. Both the ammonium and the sulphate ions seem to be involved.

On most of the soils that were tested ammonium sulphate decreased the molybdenum contents of herbage from potentially toxic to marginal or normal amounts. Calcium orthophosphate and potassium sulphate sometimes increased molybdenum and selenium uptake and the use of these fertilisers on toxic soils should be considered with caution. Liming consistently increased the molybdenum content of herbage.

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Soil Microbiology Department

General Paper

4.1 Pattison, A. C. (1972) *The Rothamsted Collection of Rhizobium. Catalogue of Strains, 1972.* Harpenden: Rothamsted Experimental Station. 12 pp.

Research Papers

4.2 Bonish, P. M. (1973) Cellulase in red clover exudates. *Plant and Soil* **38**, 307–314.

Cellulase was detected in the medium when red clover (*Trifolium pratense*) seedlings were grown aseptically in flasks. The amount of cellulase found depended on the ionic composition and pH of the medium. Cellulase was found when seedlings were grown in distilled water. With added salts the amount of cellulase detected was negligible at pH 5·5 or less, but increased with increasing pH; less was released when seedlings were grown throughout in the presence of $CaCl_2$. The enzyme may be extracytoplasmic, located on the root surface, and released by changes in the salt content and pH of the medium.

Enzyme preparations contained at least two components; one stable for at least 22 hours at pH 3·5 and 30°C, whereas the other was destroyed within 0·5 hour. The reaction rate of enzyme preparations was almost constant from pH 5 to 7.

4.3 Brown, M. E. (1972) Plant growth substances produced by micro-organisms of soil and rhizosphere. *Journal of Applied Bacteriology* **35**, 443–451.

Micro-organisms isolated from rhizospheres and rhizoplanes of wheat plants and from root-free soil, produced growth regulating substances with the properties of gibberellins or indolyl-3-acetic acid (IAA). Substances inhibiting extensions of pea plant internodes and lettuce hypocotyls were also produced, especially by bacteria from the root region of seedlings six days old. Bacteria producing growth promoting substances were most abundant on roots of older plants. Seedlings grown aseptically with added gibberellic acid (GA3) and IAA, or grown with a soil inoculum, developed similarly and differed in their morphology from those grown aseptically without additives.

4.4 Brown, M. E. (1973) Soil bacteriostasis—limitation in growth of soil and rhizosphere bacteria. *Canadian Journal of Microbiology* **19**, 195–199.

Sensitivity of soil bacteria to bacteriostasis was assessed by an agar disk method. Most bacteria isolated from wheat rhizosphere (98%) were sensitive and those not stimulated by roots were not sensitive. Bacteriostasis was always overcome by adding glucose or mineral salts. Bacteriostasis was removed partially by air-drying the soil, and totally by sterilising. Filtrates of soil extracts retained some activity unless completely sterile.

4.5 Harris, D. & Dart, P. J. (1973) Nitrogenase activity in the rhizosphere of *Stachys sylvatica* and some other dicotyledonous plants. *Soil Biology and Biochemistry* **5**, 277–279.

Stachys sylvatica, *Heracleum spondylium*, *Anthriscus sylvestris*, *Mercurialis perennis*, *Rumex acetosa*, *Convolvulus arvensis* and *Viola canina* plants on Broadbalk Wilderness have considerable nitrogenase activity associated with their roots. For *S. sylvatica* oxygen tension affected activity of roots shaken free of soil, with most at a pO_2 *c.* 0·04 atm. Activities per unit weight of root of whole plants potted in soil were 2–3 times greater than for excised roots. No direct correlation was observed between counts of nitrogen fixing organisms and activity.

4.6 Hayman, D. S. & Mosse, B. (1972) The role of vesicular-arbuscular mycorrhiza in the removal of phosphorus from soil by plant roots. *Revue d'Ecologie et de Biologie du Sol* **9**, 463–470.

Plants with vesicular-arbuscular (VA) mycorrhiza frequently absorb more phosphate from soil than those without. We have examined sources of soil P that may be more available to mycorrhizal plants. In sand with known organic phosphates added plants did not benefit from mycorr-

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hiza except on a few of these phosphates when a little soil was present which could have adsorbed some phosphate. There was a response to mycorrhiza in sand mixed with humus, but the extra phosphate absorbed could have come from the soluble pool instead of from complex organic sources. In a range of soils containing unknown sources of phosphate plants responded to mycorrhiza when there was much iron and aluminium but little available phosphorus. It is concluded from these studies, and from experiments in ^{32}P-labelled soils which indicated that mycorrhizal roots obtained their extra P from the soluble fraction, that the major role of VA mycorrhiza in increasing the uptake of soil P by roots is a physical one, namely the provision of extra absorbing surface.

4.7 Mosse, B. (1972) Effects of different Endogone strains on the growth of *Paspalum notatum*. *Nature, London* **239**, 221–223.

The tropical grass *Paspalum notatum* var. Batatais was inoculated with four different mycorrhizal fungi, one obtained from Paspalum roots grown in a Brazilian soil. The growth of the inoculated seedlings was compared in two Brazilian soils with and without lime. Both soils were so phosphate deficient that non-mycorrhizal seedlings remained extremely small in both irradiated and unsterile soil and did not benefit from added nitrogen. After liming, plants inoculated with the best mycorrhizal strain (E_3) weighed 11 times more than uninoculated controls in one soil and six times more in the other. Without added lime, plant weight increased five-fold and two-fold respectively, in the two soils. In the unsterile soils plants became infected with indigenous mycorrhizal fungi, but these only increased growth by 30% compared with non-mycorrhizal plants in the irradiated soils. Two strains of mycorrhizal fungi did not become established in the unlimed soils and in the limed soils increased growth by 2–3-fold and 4–8-fold according to the soil. A third fungal strain was most beneficial in the unlimed soil. These results indicate that strains of vesicular-arbuscular endophytes differ in their ability to promote plant growth in phosphorus deficient soils and that introduced strains may be better than indigenous ones.

4.8 Mosse, B. (1972) The influence of soil type and Endogone strain on the growth of mycorrhizal plants in phosphate deficient soils. *Revue d'Ecologie et de Biologie du Sol* **9**, 529–537.

Growth effects of seven different *Endogone* strains were compared, using seedlings of onions and of the tropical grass *Paspalum notatum* as test plants. The benefit of mycorrhizal infection depended greatly on the particular strain of *Endogone* used, varying from 2–15-fold growth increases in onions and from 2–10-fold increases in *Paspalum* according to the strain. The relative merit of a strain varied according to the soil and whether or not lime had been added; it was not always directly correlated with the intensity of infection. The establishment of mycorrhiza in rye-grass was also tested using three different *Endogone* strains in five soils, with and without added lime. Establishment of two strains appeared to be pH dependent, while the third strain became established in two soils only, irrespective of pH.

The concept of specificity is discussed with reference to vesicular-arbuscular mycorrhiza; it is suggested that effects on plant growth may depend more on interactions between a fungal strain and the soil than between a fungal strain and its host.

4.9 Mosse, B. (1973) Plant growth responses to vesicular-arbuscular mycorrhiza. IV. In soil given additional phosphate. *New Phytologist* **72**, 127–136.

The growth of mycorrhizal and non-mycorrhizal plants was compared in several soils receiving increasing amount of $Ca(H_2PO_4)_2$. In some soils mycorrhizal plants grew better at all levels of applied phosphate. In other soils, where high phosphorus concentrations built up rapidly in the plants, those with mycorrhiza grew worse when more than 0·2 g $Ca(H_2PO_4)_2$ was added per kg of soil. Because their roots take up more phosphate, mycorrhizal plants may reach supra-optimal phosphorus concentrations with smaller amounts of added phosphate.

Mycorrhiza tended to die out when 1 g $Ca(H_2PO_4)_2$ or more was given per kg soil. With much added phosphate no arbuscules were formed, many attenuated hyphae ramified through the cortex and the host seemed to have lost control over fungal development. Eventually only certain,

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morphologically distinct cells in the sub-epidermal layer were infected. With 6 g $Ca(H_2PO_4)_2$ root infection disappeared completely, but some viable inoculum survived in the soil.

4.10 SHEPHERD, A. M., CLARK, S. A. & DART, P. J. (1972) Cuticle structure in the genus *Heterodera*. *Nematologica* **18**, 1–17.

The cuticle of *H. rostochiensis* males and of the females of 14 species or pathotypes of *Heterodera* was examined with light and electron microscopes. The layers of the male cuticle resemble those of the second-stage larva and other vermiform Tylenchida so far described. The cuticle of females differs from this basic pattern in ways that fit their swollen form and sedentary habits, and their ultimate function as a protective cyst enclosing the quiescent eggs. The outer and inner layers, A and B, of males and larvae are supplemented by a third, fibrous layer, C, in lemon-shaped and round-cyst nematodes and by a fourth layer, D, in round-cyst nematodes only. The fibres in D are arranged helicoidally as in the chitin of insect endocuticle. The B layer of larvae and males is crystalloid, with disjunctions in the regular pattern at every half-annule. The periodicity of the pattern is 18–22 nm, as in one of the forms of collagen. The B layer ruptures as the females swell and ultimately occurs as separate islands at the junction of the A and C layers.

The differences in structure between the species with lemon-shaped and round cysts supports placing the round-cyst species (excluding *H. punctata*) into the separate genus *Globodera*, already suggested by Skarbilovich as a sub-genus.

4.11 SKINNER, F. A. (1972) The removal of nitrate from solution by floc-forming bacteria on decomposing cellulose particles. *Journal of Applied Bacteriology* **35**, 453–462.

Cellulose particles in aerated liquid medium inoculated with activated sludge quickly became enveloped in floccular microbial growth (cellulose floc) able to assimilate nitrate rapidly from solution. Sedimentating the floc removed assimilated nitrogen, excess cellulose and biomass. At 18 and 22°C, nitrate was removed from solution at 1·76 and 1·83 μg of nitrate-N/ml/hour, respectively. Similar results were found with floc formed by a cellulose decomposing isolate and some non-cellulolytic floc-forming bacterial contaminants. Washed preformed cellulose floc removed nitrate from dilute solution at 0·89 μg of nitrate-N/ml/hour at pH 7·1–8·6. The C : N ratio of the supernatant fluid changed rapidly as nitrate became exhausted; the significance of this is considered in relation to complete removal of C and N by further biological oxidation.

Botany Department

GENERAL PAPERS

5.1 KEYS, A. J. (1973) Biochemical aspects of the conversion of inorganic nitrogen into plant protein. *Symposium on the Biological Efficiency of Protein Production* (Reading, September 1971). Cambridge University Press, pp. 69–82.

5.2 THURSTON, J. M. (1973) Blackgrass (*Alopecurus myosuroides* Huds.) and its control. *Proceedings 11th British Weed Control Conference, 1972*, pp. 977–987.

RESEARCH PAPERS

5.3 BIRD, I. F., CORNELIUS, M. J., KEYS, A. J. & WHITTINGHAM, C. P. (1972) Oxidation and phosphorylation associated with the conversion of glycine to serine. *Phytochemistry* **11**, 1587–1594.

Particles separated from extracts of tobacco leaves by differential centrifugation catalysed the conversion of two molecules of glycine to one molecule of serine and one of carbon dioxide. The catalytic system was inhibited by inhibitors of the mitochondrial electron transport system. The reaction was slow in the absence of oxygen but attained a maximum rate with 3% by volume of oxygen in the atmosphere. Approximately one atom of oxygen was taken up for each molecule of serine formed. Added ADP increased the rate of reaction and was converted to ATP. Some

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ATP was formed and oxygen consumed in the absence of glycine but both processes proceeded faster when glycine was added. Isonicotinyl hydrazide, an inhibitor of serine synthesis, decreased phosphorylation more in the presence of glycine than in its absence. *Trans*-aconitate, a competitive inhibitor of aconitase, did not inhibit the phosphorylation caused by adding glycine but strongly inhibited phosphorylation occurring in the absence of glycine. Phosphorylation accompanying the conversion of glycine to serine probably involves the electron transport chain of mitochondria and associated phosphorylation sites. The conversion of glycine to serine is probably responsible for the evolution of carbon dioxide in photorespiration; the results suggest that photorespiration causes ATP to be synthesised in mitochondria during photosynthesis.

5.4 BIRD, I. F., CORNELIUS, M. J., KEYS, A. J. & WHITTINGHAM, C. P. (1972) Adenosine triphosphate synthesis and the natural electron acceptor for synthesis of serine from glycine. *Biochemical Journal* **128**, 191–192.

Molecular oxygen or ferricyanide were equally effective as electron acceptors for the conversion of glycine to serine in the presence of mitochondria from tobacco leaves. With ferricyanide, the rate of phosphorylation of ADP was half that when oxygen was the electron acceptor. Half the maximum rate of serine synthesis occurred when reaction mixtures were in equilibrium with an atmosphere containing 0·4% by volume of oxygen (approx. $5 \times 10^{-6} M$ oxygen in solution). Antimycin A strongly inhibited serine synthesis but amytal was only a weak inhibitor. Therefore the conversion of glycine to serine does not involve endogenous NAD in mitochondria but an electron carrier coupled to the mitochondrial electron transport chain between the energy conserving sites I and II. As a consequence of the flow of electrons along the chain to the terminal oxidase system, two molecules of ATP are synthesised for each molecule of serine formed from glycine.

5.5 BIRD, I. F., CORNELIUS, M. J., (DYER, T. A.) & KEYS, A. J. (1973) The purity of chloroplasts isolated in non-aqueous media. *Journal of Experimental Botany* **24**, 211–215.

By measuring the relative amounts of high-molecular-weight ribonucleic acids in chloroplasts and in cytoplasm reliable values were obtained for the purity of chloroplasts isolated in non-aqueous media from leaves of tobacco (*Nicotiana tabacum*, var. White Burley), broad bean (*Vicia faba*, var. White Fan), and tomato plants (*Lycopersicum esculentum*, var. Money Maker). Measurements of pyruvate kinase activity, previously used to test chloroplast purity, agreed well with the results of ribosomal ribonucleic-acid analysis for the bean and tomato leaves. The purest chloroplast fractions from tobacco leaves always contained more pyruvate kinase than could be accounted for on the basis of the cytoplasmic contamination measured by the nucleic-acid analysis. Some pyruvate kinase may therefore be present in the chloroplasts in tobacco leaves. The purest chloroplasts obtained from any of the three species still contained 11% cytoplasm even after severe mechanical treatments designed to remove cytoplasm adhering to the surface of the plastids. Chloroplast fractions obtained by the usual non-aqueous techniques always contained at least 15% of the cytoplasm.

5.6 LAWLOR, D. W. (1972) An automatic multichannel thermocouple psychrometer based on an operational amplifier. *Journal of applied Ecology* **9**, 581–588.

An automatic multichannel selector system and a simple, inexpensive amplifier are described for recording the output from Richards and Ogata droplet thermocouple psychrometers or Spanner thermocouple psychrometers. Agreement was good between the water potentials of wheat leaves measured by the Richards and Ogata psychrometers and a pressure chamber.

5.7 LAWLOR, D. W. (1973) Growth and water absorption of wheat with roots at different water potentials. *New Phytologist* **72**, 297–305.

The growth and water transport of wheat plants was measured with the root system divided into two equal parts and grown in solutions of different osmotic potential. Growth of roots decreased with the decrease in osmotic potential and stopped at −10 bar, but solutions of large osmotic potential, available to part of the root system, did not significantly influence the growth of the other part of the root system if this was at small osmotic potential. However, it did allow

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greater growth of leaves and higher transpiration rates, because plant-water potential was not greatly decreased. The rate of water transport slowed with decreasing osmotic potential but, with part of the root system under stress, absorption from solutions of high potential increased. The resistance of the parts of the root system and plant increased approximately logarithmically with decreasing leaf-water potential from −4 to −17 bar. Roots are influenced by the potential of water at their surface, but a decrease in water absorption by part of the root is compensated by an increase in water absorption by other roots, which maintains transpiration, plant-water potential and leaf growth near optimum.

5.8 WATSON, D. J., MOTOMATSU, T., LOACH, K. & MILFORD, G. F. J. (1972). Effects of shading and of seasonal differences in weather on the growth, sugar content and sugar yield of sugar-beet crops. *Annals of Applied Biology* **71**, 159–185.

In 1967 and 1968 field grown crops were shaded at specific stages of their growth. Although 1967 was sunny and dry and 1968 dull and wet, the yields of dry matter and sugar in the unshaded crops were similar because the lower net assimilation rate in 1968 was compensated for by much increased leaf area. In both years, at any stage of growth, shading decreased the net assimilation rate and resulted in a reduction in final yield. Shading greatly decreased the supply of photosynthate to the roots but it did not change the sugar percentage of dry matter. Therefore although the percentage in fresh roots was consistently decreased by shading this was wholly because the water content of the plants was increased. It was concluded that over a wide range of photosynthate supplied the root maintains a nearly constant proportion of sugar to non-sugar.

5.9 WHEELER, A. W. (1972) Changes in growth-substance contents during growth of wheat grains. *Annals of Applied Biology* **72**, 327–334.

Samples of grains growing in the ears of Kloka wheat plants were extracted at weekly intervals from ear emergence until maturity and the growth substances estimated by bio-assay. Immature grains contained two cytokinins; one was similar to zeatin, but the other, with most cytokinin activity, had different properties. Ovules contained only small amounts of growth substances but at the end of anthesis the grains had a maximum content of cytokinin. The gibberellin content increased until three weeks after anthesis then decreased; the auxin content increased until four weeks after anthesis but decreased as the grains ripened and lost fresh weight. The husks contained smaller amounts of growth substances than the grains they surrounded. Exudates from young stems contained cytokinins and these may originate in the roots and move to the ears through the stems. The auxin in the grains was identified as indole-3-acetic acid and may be derived from the phenols present reacting with tryptophane.

5.10 WILLIAMS, E. D. (1972) Growth of *Agropyron repens* seedlings in cereals and field beans. *Proceedings 11th British Weed Control Conference, 1972*, pp. 32–37.

Two experiments are described in which the growth of *Agropyron repens* seedlings was studied in field crops. In one *A. repens* seeds were sown singly in rows of winter wheat, spring wheat and spring barley with or without added nitrogen and in the other, sown thickly in plots of beans or barley undersown with ryegrass, clover or nothing.

Few seedlings established in the winter wheat but in the spring cereals half the seeds sown produced seedlings and the amount of growth made depended greatly on when they emerged. Nitrogen increased the growth of seedlings more in spring wheat than in spring barley probably because spring barley itself responded more to nitrogen than did spring wheat making it compete more with the weed. By late August about 8% of the seedlings had rhizomes and these were ones that emerged early.

In the second experiment more seedlings survived and grew better in beans than in barley. Much rhizome was produced in beans but none in barley. Undersowing in both crops decreased weed growth, relatively more in beans than in barley, and clover was more suppressive than ryegrass.

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Biochemistry Department

Thesis

6.1 Arkcoll, D. B. (1972) Studies on the production and processing of leaf protein. Ph.D. Thesis, London University.

General Papers

6.2 Pirie, N. W. (1972) Frederick Charles Bawden. *Rothamsted Experimental Station. Report for 1971*, Part 1, 34–39.

6.3 Pirie, N. W. (1972) Frederick C. Bawden 1908–1972. *Journal of General Microbiology* **72**, 1–7.

6.4 Pirie, N. W. (1972) Potential protein sources for human food. In: *Perspectives in nutrition*. Ed. R. Rajalakshmi, University of Baroda Press. 93–102.

6.5 Pirie, N. W. (1972) Plant proteins as human food. In: *Protéines et acides aminés en nutrition humaine et animale*. Ed. C. L. de Cuenca, Editorial Garsi: Madrid, 192–202.

6.6 Pirie, N. W. (1973) The way ahead? In: *The chemistry, biology and physics of protein evaluation*. Ed. G. Porter, Academic Press. pp. 537–540.

6.7 Pirie, N. W. (1972) The direction of beneficial nutrional change. *Ecology of Food and Nutrition* **1**, 279–294.

6.8 Pirie, N. W. (1973) Research on leaf protein and its application. *Archivos Latino-Americanos de Nutricion* **22**, 507–517.

6.9 Pirie, N. W. (1972) Introduction: Principles of 'mini-life'; and Closing remarks. In: *Pathogenic mycoplasmas*. Eds. K. Elliott and J. Birch, Elsevier: Amsterdam, 1–15 and 387–388.

6.10 Pirie, N. W. (1972) Biogenesis. In: *Marxism, Communism and Western Society: a comparative encyclopedia*, 256–259. Verlag Herder, Freiburg.

6.11 Pirie, N. W. (1972) Avery in retrospect. *Nature, London* **240**, 572.

Research Papers

6.12 Bawden, F. C. & Pirie, N. W. (1972) Factors affecting the amount of tobacco mosaic virus nucleic acid in phenol-treated extracts from tobacco leaves. *Proceedings of the Royal Society London B* **182**, 297–318.

Extracts from the lower leaves of tobacco plants infected with tobacco mosaic virus and pulped in the presence of phenol are less infective than extracts from leaves pulped and then treated with phenol. Extracts from uninfected leaves mixed with purified virus behave similarly. The difference becomes progressively smaller as leaves are taken from further up the plant.

The difference is smaller when the interval between pulping and adding phenol is short, and it is still smaller if air is rigidly excluded during the interval.

Fixation of virus nucleic acid to the leaf fibre is the main factor responsible for this difference. Part of the normal nucleic acid of the leaf is fixed similarly. Fixation is partly prevented by including yeast nucleic acid in the extraction fluid, or by excluding Ca^{2+} from it by adding citrate. Part of the nucleic acid is held tenaciously by the fibre.

The possible significance of this fixation *in vivo* in controlling the apparent susceptibility to infection of plants in different physiological states is discussed.

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6.13 BAWDEN, F. C. & PIRIE, N. W. (1972) The inhibition, inactivation and precipitation of tobacco mosaic virus nucleic acid by components of leaf extracts. *Proceedings of the Royal Society London B* **182**, 319–329.

Unless calcium is removed from leaf extracts containing tobacco mosaic virus nucleic acid, infectivity measurements are invalid. In some circumstances, calcium, nicotine and spermine can prevent the movement of nucleic acid into the water phase when extracts are made in the presence of excess phenol. The concentrations needed for this effect are greater than those usually found in leaf extracts, but it is possible that association of the virus with these substances produces local concentrations large enough to influence the infectivity of extracts.

6.14 FESTENSTEIN, G. N. (1972) Water-soluble carbohydrates in extracts from large-scale preparation of leaf protein. *Journal of the Science of Food and Agriculture* **23**, 1409–1415.

Soluble carbohydrate accounted for about half of the 2% dry matter in liquors from heat-coagulated leaf extracts made during large-scale preparation of protein from agricultural crops. The fraction soluble in 80% ethanol contained on average three-quarters of the total carbohydrate and the sugars were fructose, glucose and sucrose, with traces of xylose. The insoluble fraction was mostly fructosan in ryegrass, there was less in lucerne and very little in mustard; other sugars besides fructose released on acid hydrolysis were arabinose, glucose, galactose and xylose.

6.15 GLENCROSS, R. G., FESTENSTEIN, G. N. & KING, H. G. C. (1972) Separation and determination of isoflavones in the protein concentrate from red clover leaves. *Journal of the Science of Food and Agriculture* **23**, 371–376.

Oestrogenic isoflavones were extracted from the protein concentrate of red clover leaves, isolated on columns of Sephadex G-25 using 0·1*M* ammonia, and determined spectrophotometrically in the eluted fractions. Most of the chlorophyll and its breakdown products were precipitated from the original aqueous ethanolic extract before the lipids, and then the isoflavones were finally extracted.

6.16 HILL, J. M. (1973) Silica gel as an insoluble carrier for the preparation of selective chromatographic adsorbents. The preparation of 8-hydroxyquinoline substituted silica gel for the chelation chromatography of some trace metals. *Journal of Chromatography* **76**, 455–458.

Amino propyl silica gel made by treating chromatographic grades of silica gel with 3-amino propyl triethoxy silane, is reacted with p-nitrobenzoyl chloride and the $—NO_2$ group reduced to $—NH_2$ with sodium dithionite. Diazotisation and reaction with 8-hydroxyquinoline produces a dark red silica gel derivative which can be used to remove, concentrate and separate trace amounts of copper and other biologically important trace-metal cations from solutions of high ionic strength. The preparation of other selective adsorbents with different reactive groups is discussed.

6.17 HOLDEN, M. (1972) Effects of EDTA and other compounds on chlorophyll breakdown in detached leaves. *Phytochemistry* **11**, 2393–2402.

Degradation of chlorophyll was inhibited in the dark in detached leaves floating on neutral EDTA solutions, but was stimulated in the light. Salts of inorganic and organic acids, surface active agents and herbicides, in different ranges of concentrations, likewise prevented breakdown of chlorophyll in the dark and caused it to be photo-oxidised in the light. Kinins inhibited degradation in the dark but did not promote bleaching in illuminated leaves.

6.18 NOWAKOWSKI, T. Z. & BYERS, M. (1972) Effects of nitrogen and potassium fertilisers on contents of carbohydrates and free amino acids in Italian ryegrass. II. Changes in the composition of the non-protein nitrogen fraction and distribution of individual amino acids. *Journal of the Science of Food and Agriculture* **23**, 1313–1333.

(For summary see No. 2.23.)

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6.19 OLSSON, R. (1972) The effect of light on tobacco mosaic virus (TMV) formation. *Physiologia Plantarum* **27**, 9–12.

Discs were punched from TMV-inoculated tobacco leaves (*Nicotiana tabacum*) and illuminated while floating on half strength Vickery's solution maintained at 24°C. After 48 hours some discs were placed in the dark for 24 hours and the amount of TMV formed in the light and dark compared. Discs from young leaves formed more virus in the light than in the dark, whereas discs from older leaves, although they formed less virus, formed as much in the dark as in the light.

6.20 OLSSON, R. (1972) Effect of light on tobacco mosaic virus formation under anaerobic conditions. *Physiologia Plantarum* **27**, 56–59.

Tobacco leaf discs, infected with tobacco mosaic virus (TMV), were floated on Vickery's solution and kept under N_2 in the light, conditions where the only source of ATP was assumed to be cyclic photophosphorylation. Usually the virus content was unaltered or decreased during the next 24 hours; occasionally there was some TMV formation, but less than in air and light, and it was abolished by $10^{-5}M$ DCMU. This suggested that ATP produced by cyclic photophosphorylation was not used in TMV formation. Infected discs exposed to N_2 for longer than two hours formed less virus when transferred to air and light than discs not exposed to N_2, presumably because some breakdown in the TMV-forming apparatus occurred in ATP deficient conditions.

6.21 PIERPOINT, W. S. (1973) PVX-Q: An infective product of potato virus X and a leaf o-quinone. *Journal of General Virology* **19**, 189–199.

When potato virus X (PVX) is exposed to enzymically oxidising chlorogenic acid, and re-isolated, some of its properties are changed. Its UV spectrum is modified and centrifuged pellets are coloured: its UV fluorescence is diminished, and a longer-wave fluorescence is introduced: it produces less colour with 2 : 4 : 6 trinitrobenzene sulphonic acid, and moves faster in an electrical field. There is, however, little or no loss of infectivity in the course of the reaction. The results suggest that PVX combines with chlorogenoquinone to produce a modified but infective virus (PVX-Q) and it is thought that this reaction may occur naturally.

Plant Pathology Department

BOOK

7.1 GREGORY, P. H. (1973) *The microbiology of the atmosphere.* 2nd Edition. London: Leonard Hill. 377 pp.

GENERAL PAPERS

7.2 COCKBAIN, A. J. (1972) Aphids. In: *Encyclopedia of the animal world.* Elsevier International Projects Ltd. pp. 90–94.

7.3 GOVIER, D. A. & PLUMB, R. T. (1972) Henbane mosaic virus. *Commonwealth Mycological Institute/Annals of Applied Biology, Descriptions of plant viruses* No. 95.

7.4 GREGORY, P. H. (1971) Black pod disease: the future. *Report of the 3rd International Cocoa Research Conference, Accra 1969*, pp. 365–369.

7.5 GREGORY, P. H. (1972) Cocoa: the importance of black pod disease. *SPAN* **15**, 30–31.

7.6 GREGORY, P. H. (1972) Obituary: Sir Frederick C. Bawden, F.R.S. *International Newsletter Plant Pathology* **2**, 2–3.

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7.7 GREGORY, P. H. (1972) Obituary: Sir Frederick C. Bawden, F.R.S. *Indian Phytopathology* **24**, i–iii.

7.8 KASSANIS, B. & GOVIER, D. A. (1972) Potato Aucuba mosaic virus. *Commonwealth Mycological Institute/Annals of Applied Biology. Descriptions of Plant Viruses* No. *98*.

7.9 LACEY, J. (1972) Actinomycete and fungus spores in farm air. *Journal of Agricultural Labour Science* **1**, 61–78.

7.10 LACEY, J. (1973) Actinomycetes in soils, composts and fodders. In: *Actinomycetales; characteristics and practical importance*. Eds. F. W. Skinner & G. Sykes. *Society for Applied Bacteriology Symposium* No. **2**, 127–147. London: Academic Press.

7.11 LACEY, J., PEPYS, J. & CROSS, T. (1972) Actinomycete and fungus spores in air as respiratory allergens. In: *Safety in microbiology*. Eds. D. A. Shapton & R. G. Board. *Society for Applied Bacteriology Technical Series* No. **6**, 151–184.

7.12 LAPWOOD, D. H. (1972) *Streptomyces scabies* and potato seed diseases. In: *Actinomycetales; characteristics and practical importance*. London: Academic Press, 89–122.

7.13 MILNE, R. G. (1972) Electron microscopy of viruses. In: *Principles and techniques in plant virology*. Eds. C. I. Kado & H. O. Agrawal. Van Nostrand Reinhold Company. 76–128.

7.14 (NOBLE, M.) & GLYNNE, M. D. (1970) Wart disease of potatoes. *F.A.O. Plant Protection Bulletin* **18**, 6, 125–135.

7.15 SALT, G. A. (1971) Conifer seedling pathology. *Report on Forest Research* (*London*) *1971*, 131–133.

7.16 WATSON, M. A. (1972) Transmission of plant viruses by aphids. In: *Principles and techniques in plant virology*. Eds. C. I. Kado & H. O. Agrawal. Van Nostrand Reinhold Company. 131–167.

7.17 WATSON, M. A. & PLUMB, R. T. (1972) Transmission of plant-pathogenic viruses by aphids. *Annual Review of Entomology* **17**, 425–452.

7.18 WOODS, R. D. & TURNER, R. H. (1972) Electron microscopy in biology. *PANS* **18**, 373–385.

PAPER IN ROTHAMSTED REPORT, PART 2

7.19 SLOPE, D. B., ETHERIDGE, J. & WILLIAMS, R. J. B. (1973) Grain yield and the incidence of take-all and eyespot in winter wheat grown in different crop sequences at Saxmundham. *Rothamsted Experimental Station. Report for 1972*, Part 2, 160–167.

This paper discusses factors affecting yield of winter wheat grown after break crops and after wheat on a calcareous boulder clay soil. The soil-borne diseases take-all and eyespot were prevalent on wheat after wheat in some years, but weather and soil conditions usually seemed to be more important factors limiting yield.

RESEARCH PAPERS

7.20 BAWDEN, F. C. & PIRIE, N. W. (1972) Factors affecting the amount of tobacco mosaic virus nucleic acid in phenol-treated extracts from tobacco leaves. *Proceedings of the Royal Society London B* **182**, 297–318.

(For summary see No. 6.12.)

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7.21 BAWDEN, F. C. & PIRIE, N. W. (1972) The inhibition, inactivation and precipitation of tobacco mosaic virus nucleic acid by components of leaf extrects. *Proceedings of the Royal Society London B* **182**, 319–329.

(For summary see No. 6.13.)

7.22 (BRUNT, A. A.) & KENTEN, R. H. (1973) Cowpea mild mottle, a newly recognised virus infecting cowpeas (*Vigna unguiculata*) in Ghana. *Annals of Applied Biology* **74**, 67–74.

Cowpea mild mottle virus (CMMV), a previously undescribed virus widespread in cowpeas (*Vigna unguiculata*) in the Eastern Region of Ghana, was seed-borne in *V. unguiculata*, *Phaseolus vulgaris* and *Glycine max*, but was not trasmitted by 12 aphid species including *Aphis craccivora*, *A. fabae*, *Acyrthosiphon pisum* and *Myzus persicae*. CMMV was transmitted by inoculation of sap to 11 of 17 members of the Papilionaceae causing very severe diseases in *G. max* and *Arachis hypogea*, and to 10 of 51 species within 5 of 19 other families; it was best propagated in *G. max* and *Nicotiana clevelandii*, and assayed in *Chenopodium quinoa*. Sap from systemically infected *G. max* was infective after dilution to 10^{-3} but not 10^{-4}, after 10 minutes at 65° but not 70°, after four days at 18°C or 16 days at 2°. Lyophilised sap was infective after three years *in vacuo*.

CMMV has straight or slightly flexuous, fragile filamentous particles *c.* 13 × 650 nm which, in sap, are occasionally surrounded by a loose external spiral. Most purified virus (*c.* 5 mg per kg of leaf tissue) was obtained from *G. max* and *N. clevelandii* by clarifying leaf extracts in 0·02*M* borate buffer with chloroform, followed by 2–3 cycles of differential centrifugation and density gradient centrifugation. Virus preparations had ultraviolet absorption spectra typical of a nucleoprotein containing *c.* 5% nucleic acid, contained numerous particles without external spirals, which sedimented as a single component with a sedimentation coefficient $S^{\circ}_{20,w}$ of 165 ± 4 *S*, and contained a single polypeptide species with a molecular weight of 32 000–33 000 daltons. CMMV showed a distant serological relationship to carnation latent virus, but not to ten other morphologically similar viruses; it thus seems to be a distinct member of the carnation latent virus group, and has the cryptogram: */* : */(5) : E/E : S/Ap.

7.23 COCKBAIN, A. J. & COSTA, C. L. (1973) Comparative transmission of bean leaf roll and pea enation mosaic viruses by aphids. *Annals of Applied Biology* **73**, 167–176.

Acyrthosiphon pisum was a more efficient vector than *Myzus persicae* of bean leaf roll virus (BLRV), but the two species transmitted pea enation mosaic virus (PEMV) equally well and much more often than *Megoura viciae*. *M. viciae* did not transmit BLRV, and *Aphis fabae* did not transmit BLRV or PEMV.

BLRV and PEMV were transmitted more often by nymphs of *A. pisum* than by adult apterae or alatae that fed on infected plants only as adults, but both viruses were readily transmitted by adults that had developed on infected plants. The shortest time in which nymphs acquired BLRV was two hours, and 50% transmitted after an acquisition period of four days. Some nymphs acquired PEMV in 30 minutes and 50% in eight hours. The shortest time for inoculation of BLRV by adults was 15 minutes, but some transmitted PEMV in probes lasting less than one minute. The median latent periods of BLRV and PEMV in aphids fed for 12 hours on infected plants were, respectively, 105 and 44 hours.

Clones of *A. pisum* differed in their ability to transmit BLRV and PEMV, and efficiency in transmitting the two viruses seemed to be unrelated. Some aphids that fed successively on plants infected with each virus transmitted both viruses, and infectivity with one virus did not seem to affect transmission of the other.

7.24 COCKBAIN, A. J. & GIBBS, A. J. (1973) Host range and overwintering sources of bean leaf roll and pea enation mosaic viruses in England. *Annals of Applied Biology* **73**, 177–187.

Bean leaf roll virus (BLRV) and pea enation mosaic virus (PEMV) were each transmitted by *Acyrthosiphon pisum* (Harris) to 15 of 30 species of legumes in the glasshouse; 11 species were susceptible to both viruses. The only biennial or perennial species infected by BLRV were hop

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trefoil (*Medicago lupulina* L.), lucerne (*M. sativa* L.) and red clover (*Trifolium pratense* L.), but naturally infected sainfoin (*Onobrychis viciifolia* Scop.) and white clover (*T. repens* L.) were found. The only perennial species infected with PEMV in the glasshouse was kidney vetch (*Anthyllis vulneraria* L.).

Eggs of *A. pisum*, which seems to be main vector of BLRV and PEMV in England, were found in winter on several species of cultivated perennial legumes, most on lucerne, fewest on white clover. In spring, more viviparae of *A. pisum* were found on lucerne than on other perennial legumes, and many on lucerne, but few on red or white clover, were infective with BLRV. Lucerne is probably the main overwintering source of BLRV in areas where lucerne is common, but elsewhere red and white clovers are probably as important. No aphid collected from perennial legumes between 1965 and 1968 was infective with PEMV, but this virus can overwinter in common vetch (*Vicia sativa* L.)

7.25 (GAMS, W.) & LACEY, J. (1972) Cephalosporium-like hyphomycetes. Two species of *Acremonium* from heated substrates. *Transactions of the British Mycological Society* **59**, 519–522.

Isolates of *Acremonium* species growing well at temperatures up to 40°C are described as *Acremonium thermophilum* Gams & Lacey sp. nov. and *Acremonium flavum* Gams sp. nov. *A. thermophilum* was isolated from mouldy, self-heated sugar cane bagasse from Trinidad, while *A. falvus* came from soil and municipal compost in W. Germany and the Netherlands. Both belong to section Nectrioidea of the genus *Acremonium* but *A. thermophilum* is unique in the genus because it is thermophilic and also has pigmented hyphae.

7.26 HIDE, G. A., HIRST, J. M. & STEDMAN, O. J. (1973) Effects of skin spot (*Oospora pustulans*) on potatoes. *Annals of Applied Biology* **73**, 151–162.

King Edward and Majestic seed potatoes selected as 'clean' (macroscopically symptomless), moderate and severe according to the extent of skin spot were planted in field experiments at Rothamsted between 1964 and 1968. Usually crops from 'clean' and moderately infected seed did not differ detectably in growth or yield. Plants from severely infected seed tubers emerged more slowly, had fewer stems and yielded less (King Edward 20%, Majestic 13%). Seed infection also affected tuber size distribution; severely infected seed of King Edward yielded almost 4 tons/acre less of 1¼–2¼ in. tubers and Majestic, 1 ton/acre less of these and 2 tons/acre less 2¼–3¼ in. tubers. However, the total yield from diseased seed stocks was only slightly less (King Edward, 0·6 ton/acre and Majestic 0·8 ton/acre) than the yields from the 'clean' tubers selected from them. Seed severely infected by *Oospora pustulans* often increased infection of the progeny tubers, and usually decreased their infection by *Rhizoctonia solani* and sometimes by *Helminthosporium solani*.

Another series of experiments compared King Edward seed tubers classified according to the number of live eyes showing in March. Seed with one, two, three and more live eyes yielded equally. About half the tubers without live eyes in March eventually produced plants, but late, with few stems and giving only half the yield of seed with three or more live eyes. Surprisingly, the progeny tubers from seed without live eyes were least infected by *O. pustulans*, *R. solani* and *H. solani*.

Progenies of King Edward and Majestic seed from a common source grown on seven widely separated farms were infected more in 1963 than in 1964, but in each year infection differed widely between farms. Often where *O. pustulans* was common, *R. solani* was scarce and vice versa. By contrast, when King Edward stocks very differently infected by *O. pustulans* were grown at Rothamsted their progenies were almost uniformly infected by *O. pustulans* and *R. solani*.

7.27 HIRST, J. M., HIDE, G. A., STEDMAN, O. J. & GRIFFITH, R. L. (1973) Yield compensation in gappy potato crops and methods to measure effects of fungi pathogenic on seed tubers. *Annals of Applied Biology* **73**, 143–150.

Pathogens damage potatoes in so many ways and at so many stages of cropping, transport and storage that it is difficult to estimate their total effect. This paper describes methods used to measure how fungal pathogens affected crop health and yield, and experiments that measured

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how much the yield lost through gaps was compensated by extra growth of neighbouring plants.

Some tubers in stocks were diseased, so healthy controls were not available and contrasts could be made only by selecting grades differing in symptom severity. The differences measured represented only part of the damage because many infections are symptomless, and vigorous plants compensate for the small yields of weak or absent neighbours.

Plots gapped randomly to varying degrees at emergence or flowering showed that yields were decreased by 0·332 (± 0·129)% and 0·833 (± 0·094)% respectively, for every 1% of plants removed. When up to 24% of plants were removed the regression of percentage gaps on yield did not become significantly non-linear.

7.28 HORNBY, D. & GORING, C. A. I. (1972) Effects of ammonium and nitrate nutrition on take-all disease of wheat in pots. *Annals of Applied Biology* **70**, 225–231.

Plant debris, naturally infested with the take-all fungus (*Ophiobolus graminis*), was washed from soil and added to a leached sandy loam, deficient in nitrate nitrogen (NO_3^--N) and magnesium. Nutrient solutions containing potassium and phosphorus, with and without magnesium, were added to the amended soil unsupplemented, or with either NO_3^--N, ammonium nitrogen (NH_4^+-N), or both. Nitrification of NH_4^+-N was inhibited by 2-chloro-6-(trichloromethyl)-pyridine ('N-Serve'). After 38 days at 19°C, fewer plants had take-all with N (75 or 100 mg/kg soil) than without and root systems were most discoloured and had most diseased axes when nutrients were not added. Plants given NH_4^+-N developed less take-all when magnesium was present. A comparison of forms of N in the presence of added magnesium showed that take-all was least with a mixture of both forms of N, intermediate with NO_3^--N alone and worst with NH_4^+-N alone. The most extensive lesions on individual root axes occurred on plants given NH_4^+-N. It is suggested that take-all will be least when the amounts and ratio of NH_4^+-N and NO_3^--N are optimum for the growth of the host.

7.29 JENKYN, J. F., HIRST, J. M. & KING, G. (1973) An apparatus for the isolated propagation of foliar pathogens and their hosts. *Annals of Applied Biology* **73**, 9–13.

Epidemiological studies, especially of obligate pathogens, often require healthy test plants and the incubation of infections in isolation. Ventilation of glasshouses with spore-free air is helpful but costly, and provides only a few discrete environments. The apparatus described is cheap and simple and enables many separate covered plant pots to be supplied with filtered air. It was designed to help measure the incubation time and frequency of viable conidia of *Erysiphe graminis*, but may also be useful for studying other pathogens and, with some modification, for plant breeding or quarantine.

7.30 JENKYN, J. F. (1973) Seasonal changes in incubation time of *Erysiphe graminis* f. sp. *hordei*. *Annals of Applied Biology* **73**, 15–18.

Incubation time of *Erysiphe graminis* f. sp. *hordei* varied seasonally, but between early May and late September it was always between five and eight days. This is approximately the time of year when the 30-year weekly mean air temperature exceeds 10°C. Amount of infection during summer was decreased by hot, dry weather. In winter, incubation times were more variable and long incubation times were usually associated with few infections. Variation in incubation time during the summer is unlikely to be of practical importance in determining the rate of epidemic development.

7.31 KASSANIS, B. & CONTI, M. (1971) Defective strains and phenotypic mixing. *Journal of General Virology* **13**, 361–364.

Phenotypic mixing, i.e. mixing of the protein of one virus with the RNA of another, is not widespread. The evidence suggests that it occurs between strains one of which is defective in its protein.

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7.32 KASSANIS, B. & TURNER, R. H. (1972) Virus inclusions formed by the PM_2 mutant of TMV. *Journal of General Virology* **14**, 119–122.

Cells infected with TMV contain in their cytoplasm characteristic long electron-dense filaments of unknown nature. By comparing the fine structure of cells infected with two isolates of PM_2, which is a strain of TMV, it was possible to suggest that the long filaments consist of the excess virus protein produced beyond that needed to coat the RNA.

7.33 KASSANIS, B. & WHITE, R. F. (1972) Interference between two satellite viruses of tobacco necrosis virus. *Journal of General Virology* **17**, 177–183.

The tobacco necrosis satellite viruses SV_1 and SV_2 interfere with one another's replication, and the larger the dose of the interfering satellite the greater the degree of interference produced. The amount of interference also depends on the strain of tobacco necrosis virus (TNV) used as helper. Suppression of SV_2 by SV_1 is greater than that of SV_1 by SV_2, although SV_2 is the more infective. SV_c differs serologically from SV_1 and SV_2 no more than these two differ from each other, but it needs a different strain of TNV for replication. Nevertheless, there is no interference between SV_c and either SV_1 or SV_2. The interference between SV_1 and SV_2 takes place in the first two hours after inoculation. Satellite viruses inoculated three days after TNV do not interfere with one another provided the TNV strain is one that aids their multiplication. The results suggest that SV_1 and SV_2 compete for an early metabolite.

7.34 KASSANIS, B., WOODS, R. D. & WHITE, R. F. (1972) Some properties of potato mop-top virus and its serological relationship to tobacco mosaic virus. *Journal of General Virology* **14**, 123–132.

Potato mop-top (PMTV) and tobacco mosaic (TMV) viruses are serologically related, but only slightly. An antiserum with a titre of 1600 against TMV had a titre of only five against PMTV. Similarly, an antiserum with a titre of 2048 against PMTV had a titre of only eight against TMV; when diluted in saline this antiserum did not precipitate TMV, but did when diluted in 0·1*M* EDTA pH 7·7. Particles of PMTV were of many lengths, with peaks in the distribution of lengths at 250 to 300 nm and 100 to 150 nm. Only the longest particles were infective. They had the same width and pitch of the protein helix as TMV particles. Sap from infected leaves contained only few particles, many of which were defective; the main defect was the uncoiling of the protein from one end. Plants infected with TMW are partially protected against infection by PMTV.

7.35 KENTEN, R. H. (1972) The purification and some properties of cocoa necrosis virus, a serotype of tomato black ring virus. *Annals of Applied Biology* **71**, 119–126.

Cocoa necrosis virus (CNV) was transmitted by sap inoculation to 12 of 21 species tested. It was propagated and assayed in *Phaseolus vulgaris*. Sap from *P. vulgaris* was infective after dilution to 10^{-3} but not 10^{-4}, after ten minutes at 60°C but not 65°C, and after four but not seven days at 20–24°C. Lyophilised sap from *P. vulgaris* was infective after two years *in vacuo*.

Virus was prepared by extracting infected leaves of *P. vulgaris* with 0·1*M* phosphate (pH 7·5) containing 0·05*M* ethylene diamine tetra-acetate and 0·02*M* thioglycollate. After clarification with n-butanol, virus was purified by precipitation with polyethlene glycol and several cycles of differential centrifugation. Such preparations were very infective and contained numerous particles, 24–26 nm in diameter with a hexagonal profile, which sedimented as two components with sedimentation coefficients ($S^\circ_{20,w}$) of 101 *S* and 129 *S*. The absorption spectra of both components with maximum and minimum absorption at 259 and 240 nm respectively were typical of nucleoproteins (101 *S* component, A 260/280 = 1·63; A 260/240 = 1·40: 129 *S* component, A260/280 = 1·78; A260/240 = 1·58) and indicated nucleic acid contents of *c.* 35% for the 129 *S* component and *c.* 20% for the 101 *S* component; values calculated from the sedimentation coefficients were 41 and 30% respectively. Only the 129 *S* component seemed to be infective and was not more so when mixed with 101 *S* component. Both components contained a single protein subunit weighing *c.* 60 000 daltons.

Under certain conditions sap fractionated without butanol gave virus preparations containing empty protein shells (54 *S*) and small spherical particles (20–30 *S*) *c.* 12 nm diameter.

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CNV is a serotype of tomato blackring virus and is distantly related to Hungarian chrome mosaic virus.

The cryptogram of CNV is */* : */(35–41) : S/S : S/*.

7.36 KENTEN, R. H. & WOODS, R. D. (1973) Viruses of *Colocasia esculenta* and *Xanthosoma saggitifolium*. *PANS* **19**, 38–41.

Virus-like particles are associated with two diseases of *C. esculenta* in the Solomon Islands. Leaves with the disease known as 'Bobone' always contain bacilliform particles similar to those of lettuce necrotic yellows; leaves from plants with the lethal disease known as 'Alomae' contain similar particles but also small bacilliform particles similar to those of the cocoa swollen shoot virus group.

7.37 LAPWOOD, D. H. & ADAMS, M. J. (1973) The effect of a few days with rain on the distribution of common scab (*Streptomyces scabies*) on young potato tubers. *Annals of Applied Biology* **73**, 1–7.

At Woburn, Beds., in 1967 potato tubers formed and grew in dry soil, except after rain between 23 and 26 June. At lifting, Majestic tubers were severely and uniformly scabbed, except for distinct bands free from lesions. The position of the bands differed depending on the date when tubers started to form; they were further from the stolon attachment when tubers formed early and nearer it when tubers formed late.

Samples taken in June and July showed that the scab-free band and the late June rain were related. From 25 June to 1 July the soil was probably wet enough to prevent *S. scabies* infection, but only one or two tuber internodes remained free from infection; they were the internodes that began to expand about a week before the rain. Internodes that formed while the soil was wet became scabbed, showing they were still susceptible to *S. scabies* after the soil had dried again.

Recent work on lenticel formation has suggested a hypothesis to explain these results.

7.38 LAPWOOD, D. H., WELLINGS, L. W. & HAWKINS, J. H. (1973) Irrigation as a practical means to control potato common scab (*Streptomyces scabies*); final experiment and conclusions. *Plant Pathology* **22**, 35–41.

In 1971, irrigation at Gleadthorpe E.H.F. had little or no effect on yields but, when applied early in the season, greatly decreased common scab on the suceptible cultivars King Edward, Majestic and Desiree. Record, and especially Pentland Crown, had little scab with or without irrigation.

Most scab infection occurred during dry weather in late June and early July. Irrigation for six weeks from 4 June, at 0·6 in. (15 mm) soil moisture deficit (S.M.D.) controlled scab most effectively, but six weeks was only marginally better than four weeks. With other regimes, the severity of scab increased as the S.M.D. allowed before irrigation was increased. King Edward tubers from unirrigated plots were blemished more in 1971 than in the two previous dry seasons, partly because rain caused tubers to swell more than previously and enlarged scab lesions so much that healthy tissue between scabs was ruptured.

More tubers per plant were formed from King Edward when seed tubers were treated with benomyl and oxycarboxin before planting than when untreated, but irrigation even from 75% emergence had no effect on tuber numbers.

7.39 LAPWOOD, D. H. (1972) The relative importance of weather, soil- and seed-borne inoculum in determining the incidence of common scab (*Streptomyces scabies*) in potato crops. *Plant Pathology* **21**, 105–108.

Potato seed tubers, cv. Majestic, without or variously affected by common scab, were planted between 1964 and 1967, in two fields at Rothamsted, one known to produce only slightly scabbed and the other severely scabbed potato crops.

The amount of scab at lifting depended most on whether June or early July was wet or dry.

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If wet, there was little infection on progeny tubers irrespective of the amount of inoculum in soil or on seed tubers. When dry weather allowed infection, inoculum in soil had more effect than that on seed.

7.40 PLUMB, R. T. & TURNER, R. H. (1972) Scanning electron microscopy of *Erysiphe graminis*. *Transactions of the British Mycological Society* **59**, 149–150.

Scanning electron microscopy was used to examine conidial chain formation and conidial structure of *Erysiphe graminis*. Ridges develop around the conidial chain as it elongates and several are produced before invagination separates the distal conidia.The point of conidial attachment was examined and attempts made to correlate external and internal developmental changes

7.41 TURNER, R. H. & GREEN, C. D. (1972) Preparation of biological material for scanning electron microscopy by critical point drying from water miscible solvents. *Journal of Microscopy* **97**, 357–363.

Nematodes and mildew-infected barley leaves after critical point drying (CPD) from sulphur dioxide (critical temperature 157·7°C) showed no obvious physical damage but the specimens had a surface deposit which was probably heat damaged natural waxes. The nematode (*Caenorhabditis elegans*) and clover root (*Trifolium subterraneum*) showed no physical or heat damage after CPD from Monochlorodifluoromethane (Freon 22, critical temperature 96°C). The hyphae and conidia of unfixed mildew on barley were damaged after CPD from Freon 22, probably due to extraction of cell wall lipide by the Freon. Freon 22 was preferred for most specimens as it is cheap, easy to get and not very toxic.

7.42 WHITE, R. F., KASSANIS, B. & JAMES, M. (1972) Potato mop-top virus in infected cells. *Journal of General Virology* **15**, 175–177.

Cells of young tobacco plants cv. Xanthi, infected with potato mop-top virus, were found to contain long rods, varying in length but 19 nm in diameter. Similar rods have been described in plants infected with certain strains of TMV. This is further evidence that potato mop-top virus is a strain of TMV.

Nematology Department

BOOK

8.1 JONES, F. G. W. & DUNNING, R. A. (1972) *Sugar beet pests. Ministry of Agriculture, Fisheries and Food, Bulletin* No. 162, 3rd Edition. London: H.M.S.O. 113 pp.

THESIS

8.2 OLOWE, M. O. (1972) Taxonomy and biology of *Pratylenchus brachyurus* (Godfrey, 1929), Filipjev and Schuurmans Stekhoven, 1941 and *Pratylenchus zeae* Graham, 1951. Ph.D. Thesis, University of London.

GENERAL PAPERS

8.3 (COOK, R.) & WILLIAMS, T. D. (1972) Pathotypes of *Heterodera avenae*. *Annals of Applied Biology* **71**, 267–271.

8.4 GREEN, C. D. (1972) The structure of the females of the round-cyst nematodes. *Annals of Applied Biology* **71**, 286–289.

8.5 GREET, D. N. (1972) Electrophoresis and morphometrics of the round-cyst nematodes. *Annals of Applied Biology* **71**, 283–286.

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8.6 HOOPER, D. J. (1972) *Ditylenchus dipsaci. Commonwealth Institute of Helminthology Descriptions of plant-parasitic nematodes.* Set 1, No. 14, 4 pp.

8.7 HOOPER, D. J. (1973) Nematodes. In: *Viruses* and *Invertebrates*. Ed. A. J. Gibbs, Amsterdam: North Holland Publ. Co., Chapter 12, 213–228.

8.8 HOOPER, D. J. & (SIDDIQI, M. R.) (1972) *Trichodorus primitivus. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 1, No. 15, 3 pp.

8.9 JONES, F. G. W. (1972) Management of nematode populations in Great Britain. *Tall Timbers Conference on Ecological Pest Control by Habitat Management, Tallahassee, Fla.*, Feb. 1972, **4**, 81–107.

8.10 JONES, F. G. W. (1972) Pathotypes in perspective. *Annals of Applied Biology* **71**, 296–300.

8.11 JONES, F. G. W. (1972) Nematodes and cereals. *ADAS Quarterly Review* No. 6, 20–36.

8.12 (NELMES, A. J.), TRUDGILL, D. L. & CORBETT, D. C. M. (1973) Chemotherapy in the study of plant nematodes. *Symposia of the British Society of Parasitology (1972)* **11**, 95–120.

8.13 PARROTT, D. M. (1972) Mating of *Heterodera rostochiensis* pathotypes. *Annals of Applied Biology* **71**, 271–273.

8.14 STONE, A. R. (1972) The round-cyst species of *Heterodera* as a group. *Annals of Applied Biology* **71**, 280–283.

8.15 TRUDGILL, D. L. (1972) Electrophoresis of protein from different populations of the potato cyst-nematode. *Annals of Applied Biology* **71**, 278–280.

8.16 WHITEHEAD, A. G. (1972) Cyst-nematodes of potatoes and sugar beet; biology and control. *SPAN* **15**, 3, 114–117.

8.17 WHITEHEAD, A. G. (1973) Integrated control systems are the answer to potato eelworm. *Arable Farmer* **7**, No. 4, 74–76.

8.18 WILLIAMS, T. D. & (SIDDIQI, M. R.) (1972) *Heterodera avenae. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 1, No. 2.

RESEARCH PAPERS

8.19 EL-SHERIF, A. G. (1972) The influence of host nutrition on the morphometrics of three *Aphelenchoides* species (Nematoda : Aphelenchoidea). *Nematologica* **18**, 174–178.

The effects of nutrients on the dimensions and the sex of *Aphelenchoides sacchari* Hooper, *A. rutgersi* Hooper & Myers, and *A. dactylocercus* Hooper, were studied when each species was reared on the fungus, *Pyrenochaeta terrestris*. There were minor variations in measurements but the basic morphological characters of the species were unchanged. The ratio of body length to tail length was consistently different in the three *Aphelenchoides* species studied. *A. rutgersi* Hooper & Myers, 1971, is a valid species. Males and intersexes were observed in *Aphelenchoides sacchari* and *Aphelenchoides rutgersi*, but there was no evidence of either in *A. dactylocercus*.

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8.20 GREEN, C. D. & GREET, D. N. (1972) The location of the secretions that attract male *Heterodera schachtii*. Sch. and *H. rostochiensis* Woll. to their females. *Nematologica* **18**, 347–352.

Females of *H. schachtii* and *H. rostochiensis* secrete male attractant all over the body and not from special glands opening to the surface. More attractant is secreted around the tail of *H. schachtii* females than around the head, so the large egg sac may carry the pheromone whereas the tiny egg sac of *H. rostochiensis* does not. A correlation between the attractiveness of *H. schachtii* females and the presence of an egg sac suggests that a single mechanism may control secretions from several organs.

8.21 HOOPER, D. J. (1972) Two new species of *Trichodorus* (Nematoda : Dorylaimida) from England. *Nematologica* **18**, 59–65.

Trichodorus velatus n. sp., ♂ and ♀, is from sandy soils growing Sitka spruce seedlings, arable crops and herbaceous plants. The male resembles *T. similis* Seinhorst, 1963, but its unstriated spicules are stouter with a wider, non-cephalated, proximal end; a narrow characteristically bent central area and a distal region with a distinct subventral flange (velum). The female has smaller refractive thickenings at the vulva than *T. similis* and resembles *T. viruliferus* Hooper, 1963, but the refractive thickenings are more obvious and the vaginal cervix has more pronounced lobes in lateral view.

T. variopapillatus n. sp., ♂ and ♀, is from woodland, wet, sandy soil associated with the roots of Elder (*Sambucus nigra* L.). Some males have two, others three, ventromedian cervical papillae and the unstriated spicules are of a similar shape to those of *T. similis* but much thinner. The female has conspicuous refractive blocks at the vulva and the vaginal region is rounded.

8.22 PARROTT, D. M. & TRUDGILL, D. L. (1972) The resistance of hybrids of *Solanum tuberosum* ssp. *andigena* and *S. multidissectum* to *Heterodera rostochiensis* pathotype E. *Plant Pathology* **21**, 86–88.

Some F_1 progeny of crosses between resistant and susceptible cultivars of potato contain resistance to *Heterodera rostochiensis* pathotype E (British notation) supplementary to that conferred by genes H_1 and H_2. This resistance in hybrid K2/6 was equal to that of its parent D40 and could be incorporated in a useful resistant cultivar.

8.23 SANTOS, M. SUSANA, N. DE A. (1972) Production of male *Meloidogyne* spp. and attraction to their females. *Nematologica* **18**, 291–302.

Meloidogyine arenaria males emerged from balsam roots 40 to 139 days after inoculation. Females were seen inside roots about 30 days after inoculation. Sex and the size of males are influenced by population density: the greater the number of larvae in the roots the larger the ratio of males to females and the shorter the males. The number of the testes was not related to the size of the males.

When on agar plates females of *M. arenaria* of different ages, exposed or in galls or obtained from plants infested to different degrees, did not attract their males. Apparently males come into contact with females during random movement and are trapped next to them in pockets of water. Similarly, females of *M. hapla* and *M. thamesi* also failed to attract their males, suggesting that males of parthenogenetic species have no role in reproduction, and mating, if it occurs, is by chance.

8.24 SEYMOUR, M. K. (1973) Motion and the skeleton in small nematodes. *Nematologica* **19**, 43–48.

From studies of plant parasitic nematodes, especially *Aphelenchoides blastophthorus*, by cinematography a motor scheme relevant to much of the behaviour of small nematodes is proposed.

An anisometric cuticle, able to extend markedly in a longitudinal direction but only slightly around its circumference, surrounds viscoelastic organs which in turn enclose liquid gut contents. Longitudinal somatic muscles shorten locally and their consequent thickening creates radial forces which displace other organs, notably the gut and its contents.

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Waves of contraction and relaxation in dorsal and ventral muscles may be in or out of phase. When waves are in phase gut contents are moved, as in defaecation, or locomotion results as in criconematids. When the waves are out of phase undulatory propulsion is produced.

Radial expansion of muscle and deformation of viscoelastic body organs within an anisometric cuticle, with or without translocation of liquid elements, may also control stylet action, move sperms and eggs and be concerned in pharyngeal pumping in some rhabditids and tylenchids.

8.25 SEYMOUR, M. K. & DONCASTER, C. C. (1972) Techniques for manipulating small nematodes. *Nematologica* **18**, 261–264.

Details are given of apparatus used to observe and manipulate small soil nematodes under the microscope. An observation cell made of rigid PVC has open sides to allow insertion of micro-tools and depth can be varied in steps. Glass suction cannulae of 20 to 50 μ aperture, connected to syringes, hold nematodes securely. Finer microcannulae (5 to 10 μ aperture) can be inserted through the cuticle for pressure recording. Microdissection knives are made from plate glass slivers fused or glued to glass handles.

8.26 SEYMOUR, M. K. & DONCASTER, C. C. (1972) Defaecation behaviour of *Aphelenchoides blastophthorus*. *Nematologica* **18**, 463–468.

The mechanism of defaecation in *Aphelenchoides blastophthorus* was studied by cinemicrography. Before defaecation, the hind third to half of the body shortens, displacing the gut contents forward. In defaecation, a backward-going sequence of re-elongation followed by localised shortening in the body wall causes gut contents to fill the posterior intestine and prerectum. The faeces are isolated in the prerectum when the prerectal valve closes, pass through the rectal valve and dilate the rectum as the anterior prerectum closes, and finally are ejected when the anus opens. After defaecation the posterior body re-elongates and the prerectal valve and prerectum open: The rectal valve and rectum remain closed until the next defaecation cycle.

8.27 SHEPHERD, A. M., CLARK, S. A. & KEMPTON, A. (1973) An intracellular micro-organism associated with tissues of *Heterodera* spp. *Nematologica* **19**, 31–34.

The ultrastructure of a bacterium-like organism found living intracellularly in tissues of two *Heterodera* spp., one a population of *H. rostochiensis* Woll. from Bolivia, S. America, and the other a population of *H. goettingiana* Liebs. from Lincolnshire, England, is described. The organism is particularly abundant in the reproductive system but does not prevent the production of fertilised eggs. It closely resembles the so called 'companion symbiont' found in leaf-hopper insects, both in general morphology and in having striated inclusion bodies.

8.28 STONE, A. R. (1973) *Heterodera pallida* n. sp. (Nematoda : Heteroderidae) a second species of potato cyst-nematode. *Nematologica* **18**, 591–606.

The pathotypes of *Heterodera rostochiensis* Woll. 1923, with white or cream females are described as a new species, *Heterodera pallida*, sub genus *Globodera* Skarbilovich 1959, differing from *H. rostochiensis* in having a larger second stage larva with a stylet about 23 to 24 μm long (21 to 22 μm in *H. rostochiensis*) and basal stylet bulbs pointed anteriorly (rounded in *H. rostochiensis*); in having cysts with Granek's ratio less than 3·0 (greater than 3·0 in *H. rostochiensis*) and only 10 to 15 cuticular ridges between anus and fenestra (17 to 24 in *H. rostochiensis*) and in having females that remain white or cream (golden yellow in *H. rostochiensis*).

8.29 TRUDGILL, D. L. (1972) Influence of feeding duration on moulting and sex determination of *Meloidogyne incognita*. *Nematologica* **18**, 476–481.

Second stage *Meloidogyne incognita* larvae of different sizes were dissected from plant roots and placed in water agar to observe their development. The same population was tested in 1968 and again in 1970. Larvae which had fed for less than nine days at 22°C were unable to moult but, depending on how long they had fed, older larvae moulted to the third, fourth or fifth stage. Larvae moulted to the third stage at approximately the same age irrespective of feeding duration. Most larvae dissected from roots 10, 11 or 12 days after inoculation in 1968 became male, whereas

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older larvae became female. There was a strong correlation between mean width of larvae at the time of dissection and their subsequent development. The same population was retested in 1970, but the results were different. Fully fed second stage larvae were smaller than in 1968 and sex was no longer labile. Larvae which had fed for more than ten days, if they became sexually differentiated at all, were female. The change in the behaviour of the population was probably due to selection, between tests, of a line able to become female in poor environmental conditions as the population had been kept in isolation and was morphologically unchanged.

8.30 TRUDGILL, D. L. & PARROTT, D. M. (1972) Disc electrophoresis and larval dimensions of British, Dutch and other populations of *Heterodera rostochiensis*, as evidence of the existence of two species, each with pathotypes. *Nematologica* **18**, 141–148.

Larval measurements, female colour and the results of electrophoresis in polyacrylamide gel indicates that *H. rostochiensis* should be split into two species. Each of these species contains pathotypes, so a modified scheme of pathotype nomenclature is suggested. Although we used different test hosts, our results indicate that Dutch and British pathotypes A are identical, and the Dutch pathotype D is the same as the British E. Populations such as the Dutch pathotypes B and C, and a population from Bolivia, which all have pathotype A characteristics but can reproduce on ex *andigena* hybrids, have not so far been found in Great Britain.

8.31 TRUDGILL, D. L. & PARROTT, D. M. (1973) Effects of growing resistant potatoes with gene H_1 from *Solanum tuberosum* ssp. *andigena* on populations of *Heterodera rostochiensis* British pathotype A. *Annals of Applied Biology* **73**, 67–75.

Pure pathotype A populations of *Heterodera rostochiensis* produce a few females on ex *andigena* hybrids with the H_1 gene for resistance. As the proportion of larvae able to become female on ex *andigena* hybrids was not increased by reproducing the nematodes on such hybrids for three years, these females seem not to be genetically different from the rest of the population. The proportion increased rapidly when the initial population contained a few pathotype (species) E nematodes but again no increase in the proportion of pathotype (species) A larvae able to become female on ex *andigena* was detected and pathotype E replaced pathotype A.

8.32 TRUDGILL, D. L., EVANS, K. & (FAULKNER, G.) (1972) A fluidising column for extracting nematodes from soil. *Nematologica* **18**, 469–475.

An apparatus which uses a controlled water current passing through a sintered plate to separate nematodes from soil particles is described. Nematodes of all types and sizes can be extracted, and the apparatus is particularly useful for extracting white *Heterodera* females. Construction is simple, so the apparatus is robust and cheap. It may prove useful for extracting other small soil invertebrates, or their eggs.

8.33 WHITEHEAD, A. G. & AHMED, S. N. (1972) Effect of 'Dowco 275', a new organophosphorus nematicide on potato cyst nematode. *Plant Pathology* **21**, 155–157.

'Dowco 275' (O,O-diethyl O-(6-fluoro-2 pyridyl) phosphorothioate) at 2·5, 5 and 10 ppm in pots of sandy loam controlled potato cyst nematode (*Heterodera rostochiensis* Woll.). At 5 ppm the control was as effective as with aldicarb.

8.34 WHITEHEAD, A. G. & FRASER, J. E. (1972) Injury to field beans (*Vicia faba* L.) by *Tylenchorhynchus dubius*. *Plant Pathology* **21**, 112–113.

Pots of sterilised soil were inoculated with a few *Tylenchorhynchus dubius* (Bütschli) and barley was grown twice in the pots. Although the barley was apparently not harmed, *T. dubius* multiplied greatly. Beans (*Vicia faba* L. cv. Tarvin) were then grown in the pots and were severely damaged by the nematode. The method used could be adapted to suit other nematodes and crop plants.

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8.35 WHITEHEAD, A. G., FRASER, J. E. & (STOREY, G.) (1972) Chemical control of potato cyst-nematode in sandy clay soil. *Annals of Applied Biology* **72**, 81–88.

In sandy clay soil in Bedfordshire, potato cyst-nematode (*Heterodera rostochiensis* Woll.) was controlled and yields of Majestic potatoes greatly increased when 1·2 g aldicarb, 4·0 g fensulfothion or 10·3 g diazinon, disulphoton, 'Isolan' (1-isopropyl-3-methyl-5-pyrazolyl dimethylcarbamate) or thionazin per m² were incorporated in the topsoil before potatoes were planted. Diethyl phosphorothioates controlled *H. rostochiensis* better than dimethyl phosphates. One hundred and eleven g methyl bromide, 47·6 g carbon disulphide or 45·2 g 'D-D' per m² applied to the soil and covered with polyethylene sheeting greatly increased the yield of potatoes, but also increased the number of nematodes in the soil. Estimates of the number of larvae able to invade potato roots in treated soil after harvest and of cysts, total eggs or live eggs selected the same range of treatments as effective in controlling *H. rostochiensis*.

8.36 WHITEHEAD, A. G. & TITE, D. J. (1972) Control of stem nematode (*Ditylenchus dipsaci*) attacking onions by aldicarb and dazomet in sandy loam. *Plant Pathology* **21**, 89–92.

In a field trial in Bedfordshire, England, in 1970–71 aldicarb at 2–8 lb a.i./acre (2·2–9·0 kg/ha) and dazomet at 196–784 lb a.i./acre (220–879 kg/ha) significantly increased the yield of onions (cv. Robusta) in irrigated sandy loam inoculated with *Ditylenchus dipsaci* (stem nematode). Aldicarb and dazomet prevented *D. dipsaci* injuring onion plants, but yields were greater from treating with dazomet than with aldicarb, probably because dazomet made more nitrogen available to the crop and aldicarb damaged the seedlings.

8.37 WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. M. (1973) Control of potato cyst-nematode, *Heterodera rostochiensis*, in three soils by small amounts of aldicarb, 'Du Pont 1410' or 'Nemacur' applied to the soil at planting time. *Annals of Applied Biology* **74**, 113–118.

Aldicarb or 'Du Pont 1410' (S-methyl 1-(dimethylcarbamoyl)-N-[(methylcarbamoyl) oxy] thioformimidate) at 2·6–11·2 kg a.i./ha applied to the soil at planting time controlled potato cyst-nematode, *Heterodera rostochiensis* Woll., in sandy loam, peaty loam and silt loam and greatly increased tuber yields of susceptible potatoes. 'Nemacur' (O-ethyl-O-(3-methyl-4-methylthiophenyl) isopropylamido-phosphate) controlled potato cyst-nematode in sandy loam at 2·9–10·3 kg a.i./ha and in silt loam at 11·2 kg a.i./ha but did not control the nematode in peaty loam even at 22·4 kg a.i./ha. In peaty loam aldicarb and 'Nemacur' were more effectively incorporated by rotary cultivation than by a modified power harrow.

8.38 WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. (1973) Effects of 'D-D', 'Telone' or dazomet applied to potato ridges in spring on potato cyst-nematode, *Heterodera rostochiensis*, in sandy loam and silt loam soils. *Annals of Applied Biology* **74**, 105–111.

Large amounts of dazomet (329, 439 kg/ha) applied to potato ridge soil in spring, before potatoes were planted, controlled potato cyst-nematode (*Heterodera rostochiensis* Woll.) in sandy loam and silt loam more effectively than large amounts of 'D-D' (359, 448 kg/ha). In heavily infested sandy loam, 329 kg dazomet/ha or 857 kg methyl bromide/ha applied in spring 1969 or 439 kg dazomet/ha applied in autumn 1968, greatly decreased the number of larvae able to invade potato roots, so Majestic potatoes grew and yielded well without increasing the number of nematodes left in the soil after harvest. Large amounts of 'D-D' or 'Telone' applied to the top-soil in autumn or to the ridges in spring were less effective in controlling potato cyst-nematode or increasing potato yields. Applied in spring 1969 to silt loam ridges, 439 kg dazomet/ha had more effect on potato cyst-nematode and increased yields of Majestic potatoes more than 448 kg 'D-D'/ha. The yield of Maris Piper potatoes (resistant to *H. rostochiensis* pathotype A) in infested silt loam was increased greatly by 'D-D', as much by 112 as by 224 or 448 kg/ha.

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8.39 WHITEHEAD, A. G., TITE, D. J. & FRASER, J. E. (1973) Control of potato cyst-nematode, *Heterodera rostochiensis*, in sandy loam, by 'Du Pont 1410' (S-methyl 1-(dimethyl-carbamoyl)-N-[(methylcarbamoyl) oxy] thioformimidate) applied to the soil at planting time. *Annals of Applied Biology* **73**, 325–328.

When applied to heavily infested sandy loam soil at planting time, as little as 5 ppm 'Du Pont 1410' (S-methyl 1-(dimethyl-carbamoyl)-N-[(methylcarbamoyl) oxy] thioformimidate) in pots, or 2·5 ppm in field plots, effectively controlled potato cyst-nematode, *Heterodera rostochiensis* Woll., and greatly increased the growth and yield of susceptible potatoes. Dipping the shoots of potted King Edward potatoes once in aqueous solution containing 2000 ppm did not control potato cyst-nematode. Nematode control was not increased when 2 or 4 kg a.i./ha was sprayed on the foliage of young Pentland Crown potatoes growing in soil already treated with the nematicide.

8.40 WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. M. (1973) Control of potato cyst-nematode, *Heterodera rostochiensis*, in silt and peat loams by ten pesticides applied to the soil of planting time. *Annals of Applied Biology* **73**, 197–201.

Incorporated in silt or peat loam topsoil in spring before susceptible potatoes were planted, three carbamoyl oximes, aldicarb, 'Tirpate' (2,4-dimethyl-2-formyl 1-1,3-dithiolane oxime N-methylcarbamate) and 'Du Pont 1410' (S-methyl 1-(dimethylcarbamoyl)-N((methylcarba-moyl) oxy) thioformimidate) and one organophosphate, 'Nemacur' (O-ethyl-O-(3-methyl-4-methylthiophenyl)-isopropylamidophosphate) all at 11·2 kg a.i./ha greatly increased the yield of tubers and effectively controlled potato cyst-nematode (*Heterodera rostochiensis* Woll.). At the same dosage thionazin was as effective in the peat loam but was ineffective in the silt loam; phorate and 'Mocap' (O-ethyl S,S-dipropyl phosphorodithioate) were less effective and chlor-fenvinphos, diazinon and a coarse granule formulation of fensulfothion were ineffective in controlling potato cyst-nematode.

8.41 WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. (1972) Control of potato cyst-nematode *Heterodera rostochiensis*, in peaty loam soil by 'D-D' aldicarb and a resistant variety of potato. *Annals of Applied Biology* **72**, 307–312.

In peaty loam soil in Cambridgeshire, 5·2 or 10·3 kg aldicarb/ha incorporated in the topsoil before potatoes were planted controlled potato cyst-nematode (*Heterodera rostochiensis* Woll.) better than 384, 769 or 1153 kg 'D-D'/ha injected 15 cm deep into the topsoil in the preceding autumn. 10·3 kg aldicarb/ha applied in 1968 and 1969 permitted King Edward potatoes (susceptible to *H. rostochiensis*) to grow well in infested soil and prevented multiplication of pathotypes of *H. rostochiensis* on Maris Piper potatoes (resistant to *H. rostochiensis* pathotype A). Although large amounts of 'D-D' applied in 1968 and 1969 increased the yield of King Edward potatoes in both years they did not control potato cyst-nematode in the second year.

8.42 WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. (1973) Treating potato ridges in spring with aldicarb, 'D-D' or dazomet to control potato cyst-nematode, *Heterodera rostochiensis*, in sandy clay and peat loam soils. *Annals of Applied Biology* **73**, 203–210.

Applied to potato ridge soil in spring, before potatoes were planted, small amounts of aldicarb (10·3 kg/ha or less) controlled potato cyst-nematode (*Heterodera rostochiensis* Woll.) better than large amounts of dazomet (110–466 kg/ha) or 'D-D' (102–439 kg/ha). Applied in spring 1968 and 1969 to heavily infested sandy clay soil 466 kg dazomet/ha allowed Majestic potatoes to grow and yield well in both years without increasing the number of nematodes in the soil after harvest, but in peaty loam dazomet was toxic to potato plants and when applied in autumn killed fewer nematodes. 'D-D' in potato ridges in spring controlled nematodes less well than dazomet or aldicarb but 896 kg 'D-D'/ha injected in sandy clay soil in autumn increased potato yield the following year without increasing the number of nematodes after harvest.

8.43 YEATES, G. W. (1972) The oesophago-intestinal junction in the Dorylaimoidea (Nema-toda). *Journal Natural History* **6**, 343–355.

The oesophago-intestinal junction of 58 species of Dorylaimoidea (*sensu* Goodey, 1963) are

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illustrated from whole mounts and eight from sections. In the Dorylaimidae the oesophago-intestinal valve fits into the bases of the oesophagus, hasa narrow lumen and its posterior end has a non-perforate, non-muscular sheath in the intestine. Seven basic patterns of junction are proposed: dorylaimid; leptonchid (valve lumen wider, no sheath); longidorid (valve reduced); belondirid (valve lumen wide, no sheath); nygolaimid (three oesophago-intestinal glands); aporcelaimid (oesophago-intestinal disc, sheath sometimes present); actinolaimid (basal oesophageal shield, sheath sometimes present). Changes from the dorylaimid junction are correlated with factors such as presence of an oesophageal sheath or shortening of the oesophageal bulb.

Insecticides and Fungicides Department

General Papers

9.1 Burt, P. E. (1973) Factors controlling the process of poisoning by topically-applied neurotoxic insecticides. Text of paper given at the *14th International Congress of Entomology, Canberra, Australia—August 1972.*

(Obtainable from Insecticides Department, Rothamsted Experimental Station).

9.2 Graham-Bryce, I. J. (1973) Solutions to problems of soil pollution by agricultural chemicals. Proceedings of Symposium on *Pollution: Engineering and Scientific Solutions, Tel Aviv, 1972.* Ed. Barrakette, E. S., Plenum Press Inc., pp. 133–147.

9.3 Graham-Bryce, I. J. (1973) Herbicide movement and availability in soils. *Proceedings of the 11th British Weed Control Conference* **3**, 1193–1202

9.4 Stevenson, J. H. (1972) Bee poisoning in England and Wales, 1971. *Bee World* **53**, 113.

Research Papers

9.5 (Aijaz, R., Baig, M. M. H., Khan, N.) & Lord, K. A. (1972) Comparative effect of Petkolin-M and DDT on the rate of oxygen consumption of adult *Tribolium castaneum* H. *Pakistan Journal of Scientific and Industrial Research* **14**, 228–231.

Effects of 'Petkolin-M' and DDT on the respiration of *Tribolium castaneum* H. were compared. Both insecticides initially increase the rate of oxygen taken up by the test insect but 'Petkolin-M' less than DDT. The rate of respiration also increased faster with DDT. Toxicity tests indicate that 'Petkolin-M' is about 5–7 times less effective than DDT.

9.6 Callow, R. K., Greenway, A. R. & Griffiths, D. C. (1973) Chemistry of the secretion from the cornicles of various species of aphids. *Journal of Insect Physiology* **19**, 737–748.

The cornicle secretions from 28 species of aphids were examined directly by mass spectrometry and, in selected cases, by chemical and chromatographic methods. The major components of the secretions are triglycerides, the acid moieties of which are hexanoic, hexadienoic (sorbic), tetradecanoic (myristic), and hexadecanoic (palmitic) acids, with smaller amounts of C_{12} and $C_{18:1}$ acids. The mixtures from the different species fall into six groups which are readily distinguished by mass spectrometry. The composition was independent of the host plant or of the stage of development where these have been investigated. Biochemical classification is not consistent with morphological classification in the species examined.

9.7 Elliott, M. & (Casida, J. E.) (1972) Optically pure pyrethroids labelled with deuterium and tritium in the methylcyclopentenonyl ring. *Journal of Agricultural and Food Chemistry* **20**, 295.

A convenient procedure is described for preparing 100-mg quantities of (+)-pyrethrolone and (+)-allethrolone labelled with ^3H in the methyl and methylene groups of the ring and for converting them to the corresponding esters, pyrethrins I and II, and allethrin, optically and stereo-

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chemically pure and with specific activities of 317–675 mCi/mmol. Pentadeuteroallethrolone and pentadeuteroallethrin were prepared as model compounds to establish the positions of labelling. The radio-labelled esters were sufficiently stable to be used in metabolism and mode-of-action studies, because there was no evidence of interference from radiation-induced decomposition or of isotopic exchange under biological conditions.

9.8 ELLIOTT, M., FARNHAM, A. W., FORD, M. G., JANES, N. F. & NEEDHAM, P. H. (1972) Insecticidal activity of the pyrethrins and related compounds. V. Toxicity of the methylbenzyl chrysanthemates to houseflies (*Musca domestica*) and mustard beetles (*Phaedon cochleariae*). *Pesticide Science* **3**, 25–28.

The insecticidal activities to houseflies and to mustard beetles of the 19 methylbenzyl (±)-*cis*-*trans*-chrysanthemates were measured to establish the patterns of substitution that produce the greatest toxicities to these insects. The two species of insect differ in their responses to the various compounds in the series. The most active compounds to houseflies and mustard beetles are, respectively, 2,4,6- and 2,3,6-trimethylbenzyl (±)-*cis*-*trans*-chrysanthemates.

9.9 ELLIOTT, M., (GAUGHAN, L. C. & CASIDA, J. E.) (1972) Preparation of tritium-labelled tetramethylcyclopropanecarboxylic acid and insecticidal esters from it. *Journal of Agricultural and Food Chemistry* **20**, 731.

When tetramethylcyclopropanecarboxylic acid is refluxed with potassium hydroxide in [hydroxy-^{3}H]-ethylene glycol, generated *in situ* with tritiated water, the α proton exchanges with tritium, giving the specifically labelled 1-^{3}H-tetramethylcyclopropanecarboxylic acid. This, esterified with 5-benzyl-3-furylmethyl alcohol, (+)-pyrethrolone, (±)-allethrolone, or *N*-hydroxymethyl-tetrahydrophthalimide gives the 1-^{3}H-tetramethylcyclopropanecarboxylates, each with a specific activity of approximately 30 mCi/mmol. Nuclear magnetic resonance and mass spectral data for the 1-^{2}H analog of the acid (made using deuterium oxide in place of tritiated water) establishes that the only proton exchanged is that at C-1 on the cyclopropane ring.

9.10 ELLIOTT, M., JANES, N. F., (KIMMEL, E. C. & CASIDA, J. E.) (1972) Metabolic fate of pyrethrin I, pyrethrin II, and allethrin administered orally to rats. *Journal of Agricultural and Food Chemistry* **20**, 300–313.

The oral administration of radio-labelled pyrethrin I, pyrethrin II, and allethrin to rats produces several urinary metabolites, identified by chromatographic and spectroscopic analyses. Each isolated metabolite contains a *trans*-2-carboxyprop-1-enyl side chain resulting from oxidation of the chrysanthemate isobutenyl group or hydrolysis of the pyrethrate methoxycarbonyl group. Also, the *cis*-2′,4′-pentadienyl side chain of pyrethrin I and pyrethrin II is modified to give a *cis*-4′,5′-dihydroxypent-2′-enyl group, a 4′ conjugate of this diol, or a *trans*-2′,5′-dihydroxypent-3′-enyl group. Allethrin is oxidised not only at the chrysanthemate isobutenyl moiety but also at the allyl group to the 1′-hydroxyprop-2′-enyl and 2′,3′-dihydroxypropyl derivatives, or at a methyl on the cyclopropyl moiety to a hydroxymethyl derivative. Allethrin gives some chrysanthemum dicarboxylic acid and allethrolone. Rapid detoxification in mammals by these metabolic pathways is probably an important factor in the selective toxicity of pyrethroids.

9.11 EVELING, D. W. (1972) Similar effects of suspensions of copper oxycholoride and kaolin on sprayed leaves. *Annals of Applied Biology* **70**, 245–249.

When dried on leaves, aqueous suspensions of copper oxychloride and of kaolin damaged the leaves similarly. With both, the damage was correlated with the rate the leaves lost water, which increased as the size of the suspended particles of copper oxychloride decreased. The damage seemed to arise mainly from a physical effect of the particles and not from copper reacting chemically.

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9.12 GRAHAM-BRYCE, I. J., STEVENSON, J. H. & ETHERIDGE, P. (1972) Factors affecting the performance of granular insecticides applied to field beans. *Pesticide Science* **3**, 781–797.

Factors influencing the performance of various granular formulations of disulfoton and phorate after foliar application to field beans were investigated by bioassay in controlled environment rooms. Frequent rainfall and high temperature increased activity considerably but humidity had little effect. With disulfoton, formulation on pumice rather than fuller's earth, and toxicant concentrations of 7·5% rather than 10% increased toxicity, but effects of formulation were small with phorate. The influence of rainfall and formulation were confirmed in a field experiment. There was evidence for an initial fumigant effect, particularly for phorate, in both laboratory and field experiments. The detailed effects of the various factors at different intervals after applying the granules are discussed in relation to the physical properties of the insecticides and granular carriers. It is suggested that the possibilities of controlling performance by influencing release rates from granules are limited for chemicals such as phorate and disulfoton which are appreciably adsorbed by soil.

9.13 GREGORY, G. E. (1973) Simple fluorescence staining of insect central nerve fibres with Procion Yellow. *Stain Technology* **48**, 85–87.

Nerve fibres in the central nervous system of the cockroach *Periplaneta americana* can be displayed by staining whole ganglia for 1–2 hours in a saturated solution of Procion Yellow M-4R in cockroach saline diluted to maintain isotonicity. Selected fibres are stained preferentially by cutting a peripheral nerve or interganglionic connective close to the ganglion, or damaging neuron cell bodies. The ganglion is washed in saline, fixed in alcoholic Bouin, dehydrated and embedded. Under fluorescence microscopy, sections show stained fibres brilliant yellow against a green background. The method is simpler than intracellular injection and demonstrates even the finest fibres.

9.14 GRIFFITHS, D. C., JEFFS, K. A., SCOTT, G. C., (GAIR, R., LESTER, E., MASKELL, F. E. & WILLIAMS, J. H.) (1972) Biological effects of combining carboxin, organomercury fungicides and insecticides as seed dressings for wheat, and the effect of these combinations on adherence of the pesticides to the seed. *Pesticide Science* **3**, 609–618.

When seeds of winter wheat were carefully dressed in the laboratory with combinations of fungicides (organomercury alone or organomercury plus the systemic fungicide carboxin) and insecticides (aldrin, carbophenothion or chlorfenvinphos as liquid formulations, or a γ-BHC powder formulation) so as to ensure that nearly all the recommended amounts of the active ingredients stuck to them, the insecticides gave good insect control, but γ-BHC with organomercury fungicide decreased the number of plants that germinated, and γ-BHC with carboxin and organomercury was even more damaging.

Commercially dressed seeds had only about 30–60% of the target dose of fungicides, but more than 80% of the target doses of the liquid insecticides aldrin, carbophenothion and chlorfenvinphos. With combinations of powder fungicide and liquid insecticide, greater amounts of pesticide on the seed were obtained if the insecticide was put on first.

Because of unusually late sowings and little fungal infestation, neither laboratory nor commercially treated seeds provided good tests for control of smut.

9.15 JEFFS, K. A., (COMELY, D. R. & TUPPEN, R. J.) (1972) The performance of commercial dressing machinery used to apply powder formulations of gamma-BHC to cereal seeds. *Journal of Agricultural Engineering Research* **17**, 315–322.

Examination of commercial cereal seed dressing processes showed that although metering of powder and grain is satisfactory, active ingredient is lost soon after the dressed grain leaves the mixing chamber. About a quarter of the powder separates from the grain and either accumulates in the equipment or is removed by dust extractors.

The dressed seed loses a further quarter of its active ingredient during sowing.

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9.16 KAVADIA, V. S. & PHILLIPS, F. T. (1972) The uptake of [^{14}C] dieldrin via the roots of young cotton plants. *Pesticide Science* **3**, 527–532.

The stems and leaves of young cotton plants growing in nutrient solution containing a radioactive dieldrin suspension became radioactive. After two weeks, dieldrin was taken up at a constant rate which differed slightly in different environments probably because the plants transpired at different rates.

9.17 (KHAN, M. S., HUSSAIN, A., BAIG, M. M. H.) & LORD, K. A. (1971) Assay of methyl parathion and fenitrothion in crop extracts using vapour-phase separation in conjunction with gas chromatography. *Pakistan Journal of Scientific and Industrial Research* **14**, 360–363.

Methyl parathion and fenitrothion were separated and assayed by electron capture gas chromatography using a stationary phase of 5% DC-200 on Celite at 180°C. Crop extracts contained substances which interfered with the gas chromatographic assay of these insecticides. Vapour-phase separation removed these interfering materials so that 0·1 ppm of methyl parathion and fenitrothion could be assayed in spinach, cabbage, apple, and potato and 1·0 ppm in sugar-cane and cotton.

9.18 (KHAN, M. S., HUSSAIN, A.) & LORD, K. A. (1971) Comparison of gas chromatography columns for pesticide residue analysis. *Pakistan Journal of Scientific and Industrial Research* **14**, 364–367.

Four column packings, 10% DC-200 or 15% QF-1 on 80–100 mesh celite and mixtures of the two, were tested for electron-capture gas chromatographic assay of 25 insecticides or alteration products. Detection of insecticides on the 15% QF-1 column was usually more sensitive than on 10% DC-200 column and relative retention times on the two columns differed. A packing made by mixing equal amounts of celite coated with 10% DC-200 or 15% QF-1 more nearly resembled the 15% QF-1 packing than the 10% DC-200 packing. A second packing of similar composition made by mixing the silicone polymers before applying to celite more closely resembled the DC-200 packing but generally detection was less sensitive. Since the retention times on the columns differ they provide additional ways of identifying and separating insecticides.

9.19 NEEDHAM, P. H. & DEVONSHIRE, A. L. (1973) A technique for applying small drops of insecticide solution to *Myzus persicae* (Sulz.). *Pesticide Science* **4**, 107–111.

A technique is described for applying insecticide solutions accurately and rapidly to aphids. Radiochemical measurements showed that volumes of 0·02–0·2 μl could be applied accurately, and that more than 90% of the dose remained on the aphids when 0·08 μl or less was applied. There was good agreement between the radiochemical calibration and the toxicological results.

9.20 PHILLIPS, F. T. & GILLHAM, E. M. (1973) A comparison of sticker performance against rainwashing of microcapsules on leaf surfaces. *Pesticide Science* **4**, 51–57.

Polybutyl acrylates were better than other stickers of various celluloses and alginates for retaining microcapsules on surfaces subjected to 'rainwashing' tests in the laboratory. Drying periods between rainwashing periods also improved retention. Microcapsules were lost from rainwashed surfaces exponentially.

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Entomology Department

Book

10.1 Edwards, C. A. (1973) *Environmental pollution by pesticides.* London and New York: Plenum Publishing Co., 464 pp.

General Papers

10.2 Free, J. B. (1972) Current and future developments in pollination practice and research. *Report of the Central Association of the British Bee-keepers' Association*, 12 pp.

10.3 Free, J. B. (1972) Insects and crop pollination. *Ministry of Agriculture, Fisheries and Food. Short Term Leaflet* No. 144, 8 pp.

10.4 Lewis, T. (1971) Aerial baiting to control ants (bachacs) in Trinidad. *Journal of Agricultural Science of Trinidad and Tobago* **71**, 508–515.

10.5 Lewis, T. (1972) Aerial baiting to control leaf-cutting ants. *PANS* **18**, 71–74.

10.6 Lewis, T. & (Siddorn, J. W.) (1972) Measurement of the physical environment. In: *Aphid technology*. Ed. H. F. van Emden. London: Academic Press. Chapter 6, pp. 235–273.

10.7 Simpson, J. (1972) Recent research on swarming behaviour, including sound production. *Bee World* **53**, 73–78.

10.8 Taylor, L. R. & Palmer, J. P. (1972) Aerial sampling. In: *Aphid technology*. Ed. H. F. van Emden. London: Academic Press, Chapter 5, pp. 189–234.

10.9 Williams, I. H. (1972) Trap-nesting solitary bees for students of biology. *Bee World* **53**, 123–135.

Paper in Rothamsted Report, Part 2

10.10 Taylor, L. R. & French, R. A. (1973) Rothamsted insect survey. *Rothamsted Experimental Station. Report for 1972*, Part 2, 182–211.

Tables are given of four-week samples of 32 aphid species, or species groups, from 17 sites in Great Britain, Denmark and Holland during the period 26 March to 4 November 1972; annual totals of 31 species of Macrolepidoptera from 68 sites in 1970 and 72 sites in 1971; four-week totals of the lacewing, *Chrysopa carnea*, and annual totals of other lacewings for 1970, 1971 and 1972.

Research Papers

10.11 Bailey, L. (1972) *Nosema apis* in drone honeybees. *Journal of Apicultural Research* **11**, 171–174.

Drone honeybees were found to be at least as susceptible as workers to infection by *Nosema apis*, and the median infective dose was fewer than 100 spores. Nevertheless, proportionately many fewer drones than workers became infected in enzootically infected, undisturbed honeybee colonies. This suggests that infection does not spread primarily via food and water, although the comparatively few drones that become infected may receive spores from the mouthparts of comb-chewing worker bees when they obtain food from these.

10.12 Bailey, L. & Fernando, E. F. W. (1972) Effects of sacbrood virus on adult honey-bees. *Annals of Applied Biology* **72**, 27–35.

Much sacbrood virus accumulates in the brains of infected bees, especially of drones, without causing symptoms. However, infected individuals fly earlier in life than healthy bees and most infected foragers fail to collect pollen, as do bees briefly anaesthetised with carbon dioxide. The

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few infected bees that gather pollen contaminate their loads with much sacbrood virus. Infection does not shorten the lives of drones, or of workers that have been deprived of pollen, but it much shortens the prolonged lives of workers that have eaten pollen. Infected workers, healthy workers deprived of pollen, and senile individuals are unable to maintain the usual metabolic rates of bees at temperatures below 35°C, or to resist chilling.

10.13 BARDNER, R., FLETCHER, K. E., JONES, M. G. & LOFTY, J. R. (1973) Fluctuations in populations of wheat bulb fly (*Leptohylemyia coarctata* Fall.). *Annals of Applied Biology* **74**, 25–34.

Egg populations have been estimated on Broadbalk field since the early 1950s. Populations varied from 0·05–8·81 million/ha. Fewest eggs were laid when the weather was cold and wet in July and August, when adults are active.

One site was intensively studied for eight years. The numbers of eggs surviving to produce adults varied between 7% and 28%, the mean being 13%. Factors affecting survival and population size are discussed.

10.14 DIBLEY, G. C. & LEWIS, T. (1972) An ant counter and its use in the field. *Entomologia Experimentalis et Applicata* **15**, 499–508.

This portable ant counter records foraging leaf-cutting ants, or the leaf fragments they carry, along trails in tropical crops or forest. Ants intercept a light beam as they pass under a gantry between the light source and a photocell. The counter distinguishes between laden and unladen ants and works with variable but predictable efficiency, depending on the species of ant and the characteristics of the vegetation cut. The design could be modified to count other insects that habitually walk along well-defined tracks.

10.15 FREE, J. B. & WILLIAMS, I. H. (1971) The role of the Nasonov gland pheromone in crop communication by honeybees (*Apis mellifera* L.). *Behaviour* **41**, 314–318.

Honeybees were trained to forage at a dish of sucrose syrup. Those that danced on returning home showed a greater tendency to expose their Nasanov glands on later trips than those that did not dance, but, contrary to previous supposition, these two activities were not closely correlated. Each may, therefore, be released by a different stimulus or, perhaps, by a different intensity of the same stimulus.

10.16 FREE, J. B. & WILLIAMS, I. H. (1972) The transport of pollen on the body hairs of honeybees (*Apis mellifera* L.) and bumblebees (*Bombus* spp. L.). *Journal of Applied Ecology* **9**, 613–619.

Pollen is transferred between bees as they brush against each other inside the hive, so that much of the pollen on the bodies of bees having to forage comes from species other than the crop on which they are working. The pollen being collected most abundantly by a colony occurs on most of its bees. Many foraging bees still carry some 'foreign' pollen on their bodies, but because it is more diluted with pollen from the crop being worked, pollen-gatherers have proportionally less 'foreign' pollen than nectar-gatherers.

10.17 FREE, J. B. & WILLIAMS, I. H. (1972) Hoarding by honeybees (*Apis mellifera* L.). *Animal Behaviour* **20**, 327–334.

Food hoarding by groups of 50 bees kept in small cages and provided with sucrose syrup was studied. Less food was stored in a new comb than in an old one, whether the old comb had been used for storing food or rearing brood, and there was less in drone than in worker combs. The presence of light, larvae and the odour of honey discouraged syrup storing, but the presence of a queen encouraged it. The amount stored also varied with environmental temperature, the age of the bees and their previous experience including deprivation and length of confinement. Increased food in honeystomachs sometimes compensated for less stored in combs.

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10.18 FREE, J. B. & WILLIAMS, I. H. (1972) The influence of a honeybee (*Apis mellifera*) colony on egg-laying by its queen. *Entomologia Experimentalis et Applicata* **15**, 224–228.

Exchanging queens between colonies with few and many eggs, respectively, influenced the numbers of eggs these queens subsequently laid; however, the queens did not completely conform to the previous egg-laying rates of the queens with which they had been interchanged.

10.19 FREE, J. B. & WILLIAMS, I. H. (1972) Genetic determination of honeybee (*Apis mellifera* L.) foraging preferences. *Annals of Applied Biology* **72**, 1–5.

The worker progeny of several queen honeybees were reared in, and allowed to forage from, the same colony. In these identical rearing and environmental conditions, the offspring of different queens sometimes differed in the kinds of flowers they preferred to visit, thus confirming that such differences are, to some extent, innate.

10.20 JONES, M. G., BARDNER, R. & FLETCHER, K. E. (1972) Assessing the age of female wheat bulb flies (*Leptohylemyia coarctata*). *Annals of Applied Biology* **72**, 129–136.

Female wheat bulb flies containing mature eggs where caught by sweeping, by white water traps, by light traps and by suction traps 29 days after the first detected emergence, while the first batch of eggs was laid 29–58 days after first emergence. The peak period of egg-laying occurred approximately four weeks after the peak emergence. The second batch was laid 29 days after the first, when the females were eight weeks old, and the third 28 days later by females 12 or more weeks old. Many flies were infected by a fungus, probably *Entomophthora muscae*. When infection occurred early in July, fewer eggs from the first batch were laid than when infection developed later.

10.21 MACAULAY, E. D. M. (1972) Flight activity of *Plusia gamma* L. in the laboratory. *Entomologia Experimentalis et Applicata* **15**, 387–391.

Aktograph experiments showed lowered light thresholds for flight during the first three days after emergence of adult moths. Maximum flight duration was also reached at the third day. These three days probably represent the time when migration would occur in wild insects.

10.22 RAW, A. (1972) The biology of the solitary bee *Osmia rufa* (L.) (Megachilidae). *Transactions of the Royal Entomological Society of London* **124**, 213–229.

An account is given of the building and provisioning of cells in nests of *Osmia rufa*, and of the development and distribution of males and females within the nest.

10.23 (SMITH, B. D.) & LEWIS, T. (1972) The effects of windbreaks on the blossom-visiting fauna of apple orchards and on yield. *Annals of Applied Biology* **72**, 229–238.

Windbreaks of coir netting were erected in apply orchards during the flowering period in 1969 and 1970 in an attempt to increase the number of insect pollinators present. Suction traps were used to sample flying insects; insects visiting trees were sampled by examination of flowers. The sheltered zone between the windbreaks contained more of most species of insects than elsewhere. Increases in final fruit set of approximately 30% in 1969 (cv. Cox's Orange Pippin) and 20% in 1970 (cv. White Jersey) occurred in trees receiving maximum shelter, and these were due mainly to the increased abundance, and possibly increased activity, of honeybees there. Fruit size was not diminished where yields were increased.

10.24 TAYLOR, L. R. & (BROWN, E. S.) (1972) Effects of light-trap design and illumination on samples of moths in the Kenya highlands. *Bulletin of Entomological Research* **62**, 91–112.

The effect on the size of sample of 32 taxa of Macrolepidoptera, and on the index of diversity α, of various modifications of the light on Rothamsted and Muguga light traps was investigated in experiments at Muguga, Kenya, in 1968. The sample of moths from the standard Muguga mercury-vapour trap was 50 times as big as that from the standard Rothamsted tungsten trap.

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Using a mixed mercury-vapour and tungsten lamp in a Muguga trap halved the sample, as also would obscuring 60% of the light from a standard mercury-vapour lamp. Overall size of sample, direction of illumination and source of illumination all affected the proportion of different taxa in the sample, but the diversity index differed little in any of the combinations of traps, lamps and sites. Analysis of the pattern of sample distribution over the site showed that moths of all sizes were migrating downwind, and height of flight was found to be positively correlated with size. Interaction between traps and sites, combined with the differing heights of flight of the different taxa, complicated the definition of specific sample size; a three-dimensional representational model attempts to define the spatial population parameters required to define the specific sample.

10.25 WILDING, N. (1972) The effect of systemic fungicides on the aphid pathogen, *Cephalosporium aphidicola*. *Plant Pathology* **21**, 137–139.

Development of *Cephalosporium aphidicola* was inhibited *in vitro* by the fungicides benomyl and triarimol but not by dimethirimol. However, neither triarimol nor dimethirimol inhibited the fungus in individuals of the aphid, *Aphis gossypii*, that fed on cucumber plants treated with the fungicides. Plants treated with benomyl were aphicidal.

Statistics Department

GENERAL PAPERS

12.1 (ALDERMAN, G., BROWN, W. O., EDWARDS, R. A., GRIFFITHS, J. R., HOLMES, W.), LESSELLS, W. J. (MCDONALD, P., MORGAN, D. E. & RAVEN, A. M.). (1972) Report of the Ruminant Energy Requirements Working Party of the ADAS Science Arm. In: *Nutrient Standards for Ruminants*, pp. 20–84. London: Ministry of Agriculture, Fisheries & Food.

12.2 CHURCH, B. M. (1972) Analytical data for agricultural soils in England and Wales: Information from a random sample 1969, 1970. London: *Ministry of Agriculture, Fisheries & Food* (*SS/FLC/108*), 11 pp.

12.3 CHURCH, B. M. (1972) Use of fertilisers in England and Wales, 1971, with regional estimates based on 1969–1971 data. London: *Ministry of Agriculture, Fisheries & Food* (*SS/FLC/103*), 35 pp.

12.4 HILLS, M. G. (1972) Types of fertiliser used on farm crops in England and Wales, 1971. London: *Ministry of Agriculture, Fisheries & Food* (*SS/FLC/104*), 9 pp.

12.5 HILLS, M. G. (1972) Some information on fertiliser handling and the use of contract and advisory services, 1969–1971. London: *Ministry of Agriculture, Fisheries & Food* (*SS/FLC/105*), 7 pp.

RESEARCH PAPERS

12.6 (BERRYMAN, C., BATEY, T., CALDWELL, T. H.) & BOYD, D. A. (1973) Manuring of potatoes on fen silt soils in Holland, Lincolnshire. *Journal of Agricultural Science* (*Cambridge*) **80**, 269–281.

The first part of the paper describes the soils of the silt fens and the second part shows how manurial practice has evolved since the crop was first widely grown on the fen silts at the beginning of the century. The remainder of the paper gives the results of 18 manurial experiments on potatoes grown on silt soils in Holland, Lincolnshire, and relates the effects of fertilisers to the results of chemical analysis of the soils.

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12.7 (HALLIDAY, D. J., HARRIS, D. G.) & HILLS, M. G. (1973) Types of fertilisers used on farm crops in England and Wales, 1962–70. *ADAS Quarterly Review* No. 8, 164–176.

The types and concentration of compound fertilisers used during the period 1960–70 changed greatly. Information collected in the *Rothamsted/ADAS Survey of Fertiliser Practice* is used to assess the types of fertiliser applied to individual crops, and to compare the pattern of compounds used in 1962, 1966 and 1969–70 for major crops. Estimates are also given of the percentages of crop acreages which had liquid fertilisers and minor nutrients. The influence of farm size on the number and types of fertilisers used is examined.

12.8 LEECH, F. B. & WEDDERBURN, R. W. M. (1972) A method for predicting proportions of affected herds from proportions of affected animals. *Journal of Hygiene*, Cambridge **70**, 409–414.

The frequency of herds affected with 13 different diseases is shown to bear a simple relationship to the frequency of affected animals. The relationship seems to be useful for predicting proportions of affected herds.

12.9 NELDER, J. A. & WEDDERBURN, R. W. M. (1972) Generalised linear models. *Journal of the Royal Statistical Society, Series A* **135**, 370–384.

The technique of iterative weighted linear regression can be used to obtain maximum likelihood estimates of the parameters with observations distributed according to some exponential family and systematic effects that can be made linear by a suitable transformation. A generalisation of the analysis of variance is given for these models using log-likelihoods. These generalised linear models are illustrated by examples relating to four distributions; the Normal, Binomial (probit analysis, etc.), Poisson (contingency tables) and gamma (variance components).

The implications of the approach in designing statistics courses are discussed.

Field Experiments Section

RESEARCH PAPERS

14.1 DYKE, G. V. (1973) Green manuring for barley at Woburn. *Journal of Agricultural Science (Cambridge)* **80**, 11–15.

Three short-term experiments on green manuring are described. In the first, trefoil (T) and ryegrass given N (RN) (sown as alternative green manures after early potatoes) increased the yield of the following spring barley by 500–900 kg/ha where no fertiliser N was given but had no effect where 38 kg or more N was applied. In the second, by contrast, both T and RN increased the yield of barley by about 1400 kg/ha whether the barley had no fertiliser N or 38, 75, 113 kg N/ha. 10–30% of the N in the green manures T, RN was recovered in the grain; about 25% of the fertiliser N was recovered. In both experiments ryegrass without N (R) had small effects. Barley yielded much the same on plots ploughed in autumn and those ploughed in spring, with or without green manures.

The third experiment (with different treatments) suggested that the effect of trefoil was caused by the greenstuff turned in, not by any physical or microbiological change in the soil.

14.2 DYKE, G. V. (1973) Experiments to compare combine harvesters. *Experimental Husbandry* **23**, 10–15.

Two experiments were designed to compare the performance of a large and a small combine harvester on plots of different sizes of wheat and barley.

When allowance is made for the effects of blank rows at the sides of the yield areas, the mean yields estimated by the two machines differed little but the large combine underestimated the yield of very short plots (about 3 m long) by about 5%.

Between-plot differences were greater with the large machine than with the small. Averaging both experiments and plots of all lengths, the small machine gave one and a half times as much information per plot as the large.

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14.3 McEwen, J. (1972) Effects of defoliating different zones on the plant in field beans (*Vicia faba* L.). *Journal of Agricultural Science* (*Cambridge*) **78**, 487–490.

The mean yield (1970–71) of untreated spring field beans was 2750 kg grain/ha. By differentially defoliating, upper and lower limits were set for the photosynthetic contributions of four zones to this yield:

(i) stems plus pods 0–300 kg
(ii) leaves below first nine flowering node 280–1150 kg
(iii) leaves on first nine flowering nodes 720–2100 kg
(iv) leaves above first nine flowering nodes 260–1150 kg.

All zones functioned below their full photosynthetic capacity when other zones were present and it appeared that competition between zones for sites to store carbohydrate was a greater limiting factor than mutual shading.

14.4 McEwen, J. (1973) The effects of growth regulators, seed rates and row spacings on field beans (*Vicia faba* L.). *Journal of Agricultural Science* (*Cambridge*) **80**, 37–42.

Four growth regulators were tested, all of them shortened stems. Two were phytotoxic and lessened yield—2-chloroethyldimethyldodecylammonium chloride and potassium 2(3-chlorophenylcarbamoyloxy) propionate. Aminozide (previously known as B 9) did not affect yield in 1970 but increased it by 28% in 1971. The related compound, N-pyrrolidinosuccinamic acid, was tested in 1970 only and did not affect yield. Seed rates and row spacings had small effects on yield which varied with season. Growth regulators did not interact with seed rates or row spacings. Plant density and growth regulators had effects on yield via the number of stems and pods per stem. The effects of season on yield were greater and were caused via 100-grain weight. Speculative hypotheses are suggested to explain the different actions of season and treatments.

14.5 McEwen, J., Salt, G. A. & Hornby, D. (1973) The effects of dazomet and fertilizer nitrogen on field beans (*Vicia faba* L.). *Journal of Agricultural Science* (*Cambridge*) **80**, 105–110.

The mean yield of field beans grown for three consecutive years on a site infested with migratory nematodes was 1540 kg grain/ha in untreated soil and 1870 kg/ha in soil treated with dazomet.

Fertiliser nitrogen in amounts up to 250 kg N/ha decreased yield to 990 kg in untreated soil but increased it to 2220 kg in soil treated with dazomet. Fertiliser nitrogen did not affect nematode numbers or root blackening but decreased nodulation and increased mycorrhizal infection by *Endogone* sp. in untreated soil. Dazomet greatly decreased migratory nematodes of the genera *Tylenchorhynchus* and *Trichodorus* and eliminated *Pratylenchus*. It had little effect on root blackening in the top 10 cm of soil but decreased it in the next 10 cm. Infection with *Endogone* was almost eliminated.

14.6 Wilson, J. C. (1972) A spraying machine for small plot experiments. *Experimental Husbandry* **21**, 25–26.

A single-wheel, self-propelled sprayer was designed and built at Rothamsted for spraying small plots without damage to the plot area by wheelmarks or footmarks. It operates satisfactorily from side paths 1 ft (0·3 m) wide and the offset spray-boom spans 9 ft (2·7 m) of crop. Plots 18 ft (5·5 m) wide can be sprayed by working from both sides. The boom can be raised to 6 ft (1·8 m) above the ground to spray full-grown cereals.

The machine sucks from standard 5 gal (25 litres) plastic jerrycans; thus changing materials and washing the machine in the field are easy.

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Broom's Barn Experimental Station

Books

16.1 DRAYCOTT, A. P. (1972) *Sugar-beet nutrition.* London: Applied Science Publishers Ltd. ix, 250 pp.

16.2 JONES, F. G. W. & DUNNING, R. A. (1972) *Sugar beet pests. Ministry of Agriculture, Fisheries and Food, Bulletin* No. 162, 3rd Edition. London: H.M.S.O., 113 pp.

General Papers

16.3 DRAYCOTT, A. P. (1972) More profit from sugar beet. *Brown Butlin Magazine*, pp. 25–26.

16.4 DRAYCOTT, A. P. (1972) Nitrogen requirement of sugar beet. *Ministry of Agriculture, Fisheries and Food—Lindsey Farming Bulletin*, pp. 2–4.

16.5 DRAYCOTT, A. P. (1972) Tests on how much nitrogen for best yield. *Eastern Daily Press*—Sugar beet supplement, September, pp. 2–3.

16.6 HEATHCOTE, G. D. (1972) Coccinellid beetles on the East Coast. *Suffolk Natural History* **15**, 515.

16.7 HEATHCOTE, G. D. (1972) The beet leaf bug in East Anglia. *Suffolk Natural History* **16**, 43–45.

16.8 HEATHCOTE, G. D. (1972) Influence of cultural factors on incidence of aphids and yellows in beet. *I.I.R.B.* (*Journal of the International Institute for Sugar beet Research*) **6**, 6–14.

16.9 HEATHCOTE, G. D. & (CATTRALL, R. L.) (1972) A time-of-spraying trial at Witham in 1971. *British Sugar Beet Review* **40**, 180.

16.10 HEATHCOTE, G. D. (1973) Beet mosaic—a declining disease in England. *Plant Pathology* **22**, 42–45.

16.11 JAGGARD, K. W. (1972) Getting the best from sugar beet. *Cambridge Evening News Farm Supplement* February 1972.

Research Papers

16.12 BYFORD, W. J. (1972) The incidence of sugar beet seedling diseases and effects of seed treatment in England. *Plant Pathology* **21**, 16–19.

On average, 180 samples of sugar beet seed grown in England between 1958 and 1970, and examined before being steeped in ethyl mercuric phosphate (EMP), had 39% of clusters infected with *Phoma betae*. However, the fungus damaged few seedlings in commercial crops because this treatment controlled it. In 1969, *Aphanomyces* sp. was unusually prevalent in sugar beet crops. Treating EMP-steeped seed with a protectant fungicide did not, on average, significantly increase seedling emergence or final plant stand.

16.13 COOKE, D. A. & HULL, R. (1972) The effect of soil fumigation with 'D-D' on the yields of sugar beet and other crops. *Annals of Applied Biology* **71**, 59–67.

An experiment in a field where sugar beet in 1965 had suffered from Docking disorder caused by *Longidorus attenuatus* tested the effect of fumigating the soil with 374 litres/ha 'D-D' and two amounts of nitrogen fertiliser on different crop sequences between 1966 and 1969. Although severe Docking disorder did not recur in sugar beet, fumigation increased yield in each of the

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three following years. Yield of barley was increased for four years and of wheat, potatoes and ryegrass for one or two years after treatment. All plant parasitic nematodes were controlled by the first fumigation and the numbers of *L. attenuatus* increased only slowly in fumigated plots, reaching 17% of those in unfumigated plots three years after treatment. Fumigation also largely prevented infection of sugar beet by the fungus *Helicobasidium purpureum*.

16.14 DRAYCOTT, A. P. & DURRANT, M. J. (1972) The immediate and long-term value of some magnesium fertilisers for sugar beet. *Journal of Agricultural Science (Cambridge)* **79**, 463–471.

Nine five-year field experiments between 1964 and 1971 tested the effect of kainit, kieserite, magnesium and calcium limestone, and farmyard manure on yield and magnesium uptake by sugar beet and on exchangeable soil magnesium. The experiments were in the main sugar-beet growing areas on soils that contained little (12–24 ppm) exchangeable magnesium. The fertilisers were applied in the year before the first sugar-beet crop and fresh dressings of some were given to other plots each time sugar beet was grown. Kieserite increased sugar yield equally when applied in the sugar-beet seedbed or three years before the sugar beet. Magnesium limestone was effective only when the soil pH was less than 7·0. FYM greatly increased yield but the increase could not be explained entirely by the magnesium it supplied.

On average, applying 100 kg/ha magnesium (as kieserite) to the seedbed increased the magnesium concentration in dried tops and roots by about 0·135% and 0·020% respectively and the total uptake by the crop in August by 9·0 kg/ha. The same treatment applied in the sugar-beet seedbed or three or four years previously increased exchangeable magnesium in the surface 25 cm of soil by 29·0, 7·6 and 1·8 ppm respectively. Thus much of the fertiliser given to the first sugar-beet crop was lost from the plough layer for the second sugar-beet crop but the yields indicated that some of it was available from depth.

On alkaline soils, when exchangeable soil magnesium in the plough layer is 0–25, 26–50 or >51 ppm, an initial application of 100, 50 or 0 kg/ha respectively of water-soluble magnesium is needed, applied either in the previous autumn or to the sugar-beet seedbed. If the exchangeable soil magnesium before the following or subsequent sugar-beet crop is 0–15, 16–25 or >26 ppm, a further application of 100, 50 or 0 kg/ha respectively of magnesium should be given.

16.15 DRAYCOTT, A. P. & DURRANT, M. J. (1972) Comparisons of kieserite and calcined magnesite for sugar beet grown on sandy soils. *Journal of Agricultural Science (Cambridge)* **79**, 455–461.

Twenty-three experiments between 1968 and 1971 compared the effect of no magnesium, 50 and 100 kg/ha magnesium as kieserite and 100 and 200 kg/ha magnesium as calcined magnesite, on yield and magnesium uptake by sugar beet. On average, 100 kg/ha magnesium as kieserite increased the mean sugar yield of 7·55 t/ha by 0·17 t/ha whereas 200 kg/ha magnesium as calcined magnesite increased it by only 0·08 t/ha; on fields with less than 15 ppm exchangeable magnesium, the magnesium fertilisers increased sugar yield by 0·34 and 0·10 t/ha respectively and there was no response to either fertiliser when the soil contained more than 25 ppm of exchangeable magnesium.

One hundred kg/ha of magnesium as kieserite or calcined magnesite increased magnesium in the dry matter of tops by 0·091 and 0·040% and of roots by 0·013 and 0·004% respectively. Giving 100 kg/ha magnesium as kieserite or calcined magnesite increased uptake of the element in August by 5·1 and 2·6 kg/ha respectively. Differences in soil pH did not influence the uptake of magnesium from kieserite but they greatly affected uptake from calcined magnesite. On the slightly acid soils, the fertilisers were almost equally effective but at pH >7·6 little magnesium was taken up from calcined magnesite. Glasshouse experiments showed that grinding the calcined magnesite increased the availability of the magnesium.

16.16 FARLEY, R. F. & DRAYCOTT, A. P. (1973) Manganese deficiency of sugar beet in organic soils. *Plant and Soil* **38**, 235–244.

The manganese content of sugar beet grown in pots of organic soils taken from fields where crops regularly show symptoms of manganese deficiency, and the effects on it of foliar sprays of

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manganous sulphate and of manganous oxide or manganese silicate frit applied to the soil, of changing the soil pH, air-drying the soil, and growing the plants either in the glasshouse or outside were determined. All the manganese treatments increased the concentration of manganese in the plants and decreased deficiency symptoms, but increased the dry matter yield only slightly. Increasing the pH by liming greatly increased symptoms and decreased the manganese concentration in the dry matter; air-drying the soil before cropping had the opposite effect. Plants grown in pots of the same soil in the glasshouse or outdoors showed similar symptoms and had similar manganese content.

The concentration of manganese in the leaves was related to the percentage of plants with deficiency symptoms and to the concentration of 'active' soil manganese. Leaves usually had symptoms when the concentration of manganese in the dried leaves was less than 30 ppm, and always had severe symptoms when they contained less than 15 ppm Mn. The soil analyses suggest that sugar beet grown in organic soil with pH greater than 7·0 and containing less than 40 ppm 'active' soil manganese is likely to show deficiency symptoms.

16.17 LONGDEN, P. C. (1972) Effects of some soil conditioners on sugar-beet seedling emergence. *Journal of Agricultural Science* (*Cambridge*) **79**, 543–545.

Seven soil conditioners added to a sandy clay soil at Saxmundham did not benefit sugar-beet seedling emergence in four experiments in three years. In microplots at Broom's Barn free draining peat and sandy loam gave consistently more seedlings than limestone loam or flinty loam. In the laboratory, for each of three soil types, emergence was maximal only for a small soil-moisture range and decreased rapidly when soils became drier or wetter. This suggests that conditioners which increase water-holding capacity should be tested on sandy loams rather than clay soils and that seedbed preparation on heavier soils should seek to aerate them.

16.18 (SCOTT, R. K.) & LONGDEN, P. C. (1972) The production of high-quality seeds. In: *Seed ecology*, Ed. W. Heydecker. London: Butterworth. Chapter 5, 81–97.

The supply of seed for the English sugar-beet crop is discussed together with the effects of crop development and plant breeding constraints on seed production. The results of six years experiments on the effects of weather at pollination and harvest, the influence of methods of growing, plant population, nutrition, sowing and harvest dates are examined in the light of the value of the seed for growing on. How best to remove this most useful seed from the bulk as harvested is also discussed.

Soil Survey

BOOKS

17.1 (BAWDEN, M. G.), CARROLL, D. M. & (TULEY, P.) (1972) *The Land Systems.* Vol. 3. The Land Resources of North East Nigeria (Land Resources Study No. 9). *Surbiton: Land Resources Division, Overseas Development Administration*, x, 466 pp.

17.2 CRAMPTON, C. B. (1972) Soils of the Vale of Glamorgan. Harpenden: Rothamsted Experimental Station, viii, 86 pp.

17.3 FURNESS, R. R. & KING, S. J. (1972) Soils in Westmorland I: Sheet SD 58 (Sedgwick). Harpenden: Rothamsted Experimental Station, vii, 108 pp.

17.4 HODGSON, J. M. (1972) Soils of the Ludlow district. Harpenden: Rothamsted Experimental Station, ix, 139 pp.

17.5 (MURDOCK, G.), WEBSTER, R. & (LAWRENCE, C. J.) (1971) *Atlas of land systems in Swaziland. Military Vehicles & Engineering Establishment*, Christchurch, Hants., England. 49 pp.

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17.6 PALMER, R. C. (1972) Soils in Herefordshire III: Sheet SO 34 (Staunton-on-Wye). Harpenden: Rothamsted Experimental Station, vi, 89 pp.

17.7 (SCOTT, R. M.), WEBSTER, R. & (LAWRENCE, C. J.) (1971) *A land system atlas of western Kenya. Military Vehicles & Engineering Establishment*, Christchurch, Hants., England, 363 pp.

THESIS

17.8 HARROD, T. R. (1972) An examination of major events in the geomorphological evolution of south and central Kesteven. Ph.D. Thesis, University of Sheffield.

GENERAL PAPERS

17.9 BRIGGS, D. J. & COURTNEY, F. M. (1972) Ridge-and-trough topography in the north Cotswolds. *Proceedings of the Cotteswold Naturalists' Field Club*, **36**, 94–103.

17.10 CARROLL, D. M. & (KLINKENBERG, K.) (1972) Soils. In: The Land Resources of North East Nigeria, Vol. 1. *Land Resources Division, Overseas Development Administration. Land Resources Study* No. 9, pp. 84–120.

17.11 CRAMPTON, C. B. (1969) The interaction of biotic and climatic factors with soil evaluation on Gelligaer Common in South Wales, Britain. *Advancing Frontiers of Plant Science* **23**, 27–53.

17.12 CRAMPTON, C. B. (1970) Genetic aspects of soils in the Forest of Dean. *Proceedings of the Cotteswold Naturalists' Field Club* **35**, 206–13.

17.13 CRAMPTON, C. B. & (FINCH, T. F.) (1971) A comparison of soils on Coal Measures in S.W. Ireland and S.E. Wales. *The Scientific Proceedings of the Royal Dublin Society, Series B* **3**, 87–99.

17.14 JONES, R. J. A. (1972) The measurement of mean temperatures by the sucrose inversion method. *Soils and Fertilizers* **35**, 615–19.

17.15 (LAWRENCE, C. J.) & WEBSTER, R. (1972) Stereoscopic scatter diagrams for illustrating population distributions. *The Mathematical Gazette* **56**, 95–99.

17.16 MACKNEY, D. (1971) Soils of Sutton Park. *Journal of the South Staffordshire Naturalists' Society* 60–68.

17.17 STURDY, R. G. (1970) The soils of Essex. In: *A guide to countryside studies.* Essex Rural and Environmental Studies Association.

17.18 THOMASSON, A. J. (1971) Soil water regimes. *Report of the Welsh Soils Discussion Group* No. 12 96–105.

17.19 THOMASSON, A. J., REEVES, M. J. & (HOOPER, A. J.) (1972) Soils. In: *Leicester and its region.* British Association for the Advancement of Science.

PAPER IN ROTHAMSTED REPORT, PART 2

17.20 HODGE, C. A. H. (1972) The soils at Saxmundham Experimental Station. *Rothamsted Experimental Station. Report for 1971*, Part 2, 143–148.

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Research Papers

17.21 (Archer, J. R.) & Smith, P. D. (1972) The relation between bulk density, available water capacity, and air capacity of soils. *Journal of Soil Science* **23**, 475–480.

The effect of bulk density on moisture content at 50 mb tension in four soils of different textures was studied. The volumetric water content increased linearly with bulk density over a wide range of densities. Depending on texture, a maximum bulk density was reached above which continued compaction decreased the water content. This is shown to be the point at which the air capacity of the soil at this tension approaches zero. Accepting that the gravimetric wilting point depends mainly on texture, the available water capacity varies in a manner similar to the 50 mb water content.

If the relationships described are valid in the field the available water capacity and air capacity may be optimised using cultivation techniques to adjust the bulk density. The available water capacity of coarse-textured droughty soils may be increased by increasing the bulk density provided that the air capacity remains above acceptable lower limits (10–15%). Conversely, the air capacity of compacted soils with large available-water capacities could be increased by reducing the bulk density to a value corresponding to an acceptable available-water capacity. In very compacted soils a decrease in bulk density will benefit both available-water capacity and air capacity.

17.22 Evans, R. (1972) Air photographs for soil survey in lowland England: Soil Patterns. *Photogrammetric Record* **7** (39), 302–322.

Eight soil patterns are described which are visible on air photographs and useful when mapping soils. They are of two types; those associated with former estuarine and coastal marshes and those formed during the last Ice Age. Some patterns are best recorded during spring when the ground is bare of crops but other show only as crop patterns during summer.

17.23 Rudeforth, C. C. & Bradley, R. I. (1972) Soils, land classification and land use of west and central Pembrokeshire. *Soil Survey Special Survey* No. 6, 23 pp + maps.

A study of soils in parts of lowland Pembrokeshire using air photographs and characterisations of profiles in the field from pits at intervals of 1 km. The data collected was used to investigate the relationship between the soils, landscape unit and other parameters and to assess land use capability.

17.24 Webster, R. & (Beckett, P. H. T.) (1972) Matric suction to which soils in south central England drain. *Journal of Agricultural Science* (*Cambridge*) **78**, 379–387.

In a survey of soils in south-central England matric suctions were measured frequently during 1962 and 1963. Results for the period October to May are given for sites lying above the influence of the regional ground water table and show the matric suctions to which the soils drain. Sandy soils drain within two or three days to a definite capacity at about 50 mbar suction. Loams and clay loams, though from profile appearance regarded as freely drained, take up to about one week to drain to a fairly constant suction of 40–50 mbar, which can also be regarded as field capacity. However, suctions prevailing during this time are less—about 20 mbar. The prevailing suctions in clay soils are about 10 mbar in the topsoil (13 cm) and −10 mbar in the subsoil (38 cm). These soils drain slowly but steadily when rain ceases and no definite field capacity is evident. For the sandy soils, loams and clay loams, the matric suctions characterise the upper limit of the available water capacity (AWC) of the soil. The values are less than almost all previous estimates or assumed values. For the clays the upper limit of AWC remains best estimated by field sampling at the time of interest.

17.25 Webster, R. & (Burrough, P. A.) (1972) Computer-based soil mapping of small areas from sample data. I. Multivariate classification and ordination. *Journal of Soil Science* **23**, 210–221.

A 1400 m × 600 m rectangular area of north Berkshire was sampled at the intersections of a 100 m square grid, and 17 properties of the soil profile measured. The 84 sampling sites were

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classified numerically to produce a hierarchy, and the classes of the upper part of the hierarchy mapped. The mapped classes became increasingly fragmented as the number of classes increased. At the 3-class level, the classes corresponded to character space clusters and class fragmentation was not serious. Principal-component analysis of the sample data yielded a first component that accounted for 40% of the total variance and well represented the field characters used for soil classification. An isarithm map of the first component shows how the soil changes gradually over the landscape in good agreement with a soil series map made by free survey.

17.26 WEBSTER, R. & (BURROUGH, P. A.) (1972) Computer-based soil mapping of small areas from sample data. II. Classification smoothing. *Journal of Soil Science* **23**, 222–234.

Two rectangular areas 1400 m × 600 m in south-central England were sampled at the intersections of 100 m square grids, and some 20 soil properties measured. Hierarchical numerical classifications gave classes which, when mapped, were very fragmented. Fragmentation was less when the geographic locations of the sampling sites were included in the classification. Linear functions of location and contiguity constraints produce maps that are smoother, i.e. less fragmented, but are unsatisfactory in other aspects. Inverse square and exponential functions of location produce smoother maps that are quite as good as those produced without taking location into account, in that the soil is no more variable within the classes mapped.

MAPS

17.27 BULLOCK, P., HEATHCOTE, W. R., CRAMPTON, C. B. & CROMPTON, A. (1973) Soil Map, 1 : 25 000 Sheet SE 64 (Escrick), Southampton: Ordnance Survey.

17.28 FORDHAM, S. J. (1972) Soil Map, 1 : 25 000 Sheet TR 35 (Deal), Southampton: Ordnance Survey.

17.29 GEORGE, H., ROBSON, J. D. & HEAVEN, F. W. (1973) Soil Map, 1 : 25 000 Sheet TF 16 (Woodhall Spa), Southampton: Ordnance Survey.

17.30 HALL, B. R., FURNESS, R. R. & KING, S. J. (1972) Soil Map, 1 : 25 000 Sheet SD 58 (Sedgwick), Southampton: Ordnance Survey.

17.31 HODGSON, J. M., MACLEAN, A. H. & WHITFIELD, W. A. D. (1972) Soil Map, 3rd Edition, Sheet 181 (Ludlow), 1 : 63 360, Southampton: Ordnance Survey.

17.32 MATTHEWS, B. (1973) Soil Map, 1 : 25 000 Sheet SE 76 (Westow), Southampton: Ordnance Survey.

17.33 PALMER, R. C. (1972) Soil Map, 1 : 25 000 Sheet SO 34 (Staunton-on-Wye), Southampton: Ordnance Survey.

17.34 WHITFIELD, W. A. D. (1973) Soil Map, 1 : 25 000 Sheet SP 36 (Leamington Spa), Southampton: Ordnance Survey.

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