ROTHAMSTED RESEARCH

Report for 1970 - Part1

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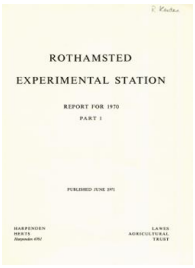

Abstracts of Rothamsted Papers

Rothamsted Research

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ABSTRACTS OF PAPERS

https://doi.org/10.23637/ERADOC-1-125

Physics Department

Thesis

1.1 Szeicz, G. (1970) Spectral composition of solar radiation and its penetration in crop canopies. Ph.D. Thesis, University of Reading.

General Papers

1.2 Penman, H. L. (1970) The water cycle. [Contribution to special number on the Biosphere.] *Scient. Am.* **223**, 99–108.

1.3 Penman, H. L. (1971) Summary paper and introduction to final discussion of I.H.D. Symposium on 'World water balance' (Reading, England, July 1970). *Bull. int. Ass. scient. Hydrol.* (Ghent). (In the press.)

1.4 Penman, H. L. (1970) Weather 1969. *Trans. Herts. nat. Hist. Soc. Fld Club* **27**.

Paper in Rothamsted Report, Part 2

1.5 Penman, H. L. (1971) Irrigation at Woburn. VII. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 147–170.

In a review of the results of 19 years of experiment, 1951–69, there is a (first) detailed analysis of the results for a grass/clover mixture, 1951–53, previously thought not amenable to such treatment because of the variable composition of the sward. The results conform to later experience with pure leys (grasses or legumes) and reveal what occurred several times for grass and other crops: at some stage in the drying of soil, plants become too dormant to be able to respond to rain, and a secondary benefit from irrigation is that it prevents this, and the crop is able to make full use of rain.

The climatological expectation of frequency of irrigation need at Woburn was seven years in ten, but over the period it occurred only ten times in 19 years. Even so, in 13 years at least one crop gave more than 20% increase in yield, in 10 years at least one crop gave more than 50% increase, and in five years at least one crop yield was doubled.

Research Papers

1.6 Brown, N. J. (1970) The influence of cultivations on soil properties. *J. Proc. Instn agric. Engrs* **25**, 112–114.

Experiments that rely only on final crop yield to evaluate cultivation operations have not shown reasons for cultivating soil, other than weed control. However, even with efficient herbicides, soil compaction from traffic is inevitable and mechanical loosening may well be necessary.

A theoretical knowledge of the mechanisms by which idealised soil physical systems function is of no immediate help to the farmer, and the semi-empirical approach of describing gross soil properties has not been rewarding.

A method is discussed of characterising soil conditions by measuring the variations that occur in the Intensity, Capacity and Rate functions of four soil physical factors: Soil Water, Soil Air, Soil Temperature and Mechanical Impedance to Roots and Shoots. These four factors have a direct influence on crop performance, and within the limits of existing knowledge, their response to cultivations is discussed within.

1.7 Currie, J. A. & Festenstein, G. N. (1971) Factors defininining spontaneous heating and ignition of hay. *J. Sci. Fd Agric.* **22.** (In the press.)

The ways in which heat balance, water balance and aeration interact in self-heating of hay beyond 70°C were examined in the laboratory. A temperature controlled environment is essential for the temperature of small hay samples to exceed 70°C; the rate air flows through the apparatus must be slower than that required below 70°C to restrict loss of latent heat caused by increased

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water transfer; otherwise air at the same relative humidity as the hay must be used. Some water is essential for hay to self-heat beyond 70°C, but self ignition occurs only when most of the water has been lost at or near 100°C. Theoretical considerations show that the latent heat transfer exceeds the thermal conductivity of hay above 20°C, increases by one order of magnitude by 65°C, two by 95°C and infinitely by 100°C.

1.8 LAKE, J. V., (POSTLETHWAITE, J. D. & SLACK, G.) (1969) Transpiration of *Helxine solierolii* and the effect of drought. *J. appl. Ecol.* **6**, 277–291.

Two experiments are described in which the influence of withholding irrigation upon transpiration was investigated, using a continuous cover of a herbaceous perennial, *Helxine solierolii*. The results are interpreted as showing that the resistance to water transport between the near-surface soil layers and the transpiring leaves was negligible when the daily transpiration rate of irrigated plants was in the range 0–4 mm. For plants well supplied with water, the stomatal resistance to water vapour transport was not negligible. Changes in the transpiration rate of plants in drying soil, relative to that of irrigated ones, were attributed to changes in the water vapour conductance of the stomata resulting from changes in soil water potential, these two factors being linearly related over a range of potentials from −1 bar to less than −20 bars. Published results for cotton and saltbush, with daily transpiration rates in the range 0–12 mm, were shown to lead to similar conclusions.

1.9 LAKE, J. V. & (SLATYER, R. O.) (1970). Respiration of leaves during photosynthesis: III. Respiration rate and mesophyll resistance in turgid cotton leaves, with stomatal control eliminated. *Aust. J. biol. Sci.* **23**, 529–535.

Mixtures of carbon dioxide in air, nitrogen, or 1% oxygen in nitrogen, prepared beforehand in plastic balloons, were passed through illuminated cotton leaves in a laboratory leaf chamber. This procedure enabled much more accurate calculation of intercellular carbon dioxide concentration than conventional gas flow techniques. It also made it possible to calculate leaf temperature from a measurement of the vapour pressure of the air leaving the chamber. From the measured flow rates and changes in the carbon dioxide concentration of the gas mixtures, the relation between the net rate of carbon dioxide exchange and the intercellular carbon dioxide concentration was calculated.

It was inferred from the results that in bright light at 27°C the basal rate of respiratory carbon dioxide production during photosynthesis in air was at least 16·3 ng cm^{-2} s^{-1}, with additional respiratory production taking place at a rate equivalent to 38% of the rate of photosynthetic fixation.

The liquid phase resistance to carbon dioxide transport within the mesophyll cells was 3·0 s cm^{-1}; this compares with a value of 4·8 s cm^{-1} which would have been inferred if respiration had not been allowed for.

1.10 MONTEITH, J. L. & BULL, T. A. (1970) A diffusive resistance porometer for field use. II. Theory, calibration and performance. *J. appl. Ecol.* **7**, 623–638.

The theory of the porometer (see 1.12) is considered in terms of static and dynamic response, the time of response, and the effect of temperature and temperature difference on response. Examples of field performance—on field beans—are given to show the good degree of reproducibility of readings, and some features of stomatal changes during a day, the variation of stomatal resistance with height in the canopy, and its seasonal changes.

1.11 PARKINSON, K. J. (1971) Carbon dioxide infra-red gas analysis: Effects of water vapour. *J. exp. Bot.* **22**. 169–176.

Theory shows that it is nearly always necessary to correct carbon dioxide infra-red gas analyses for the presence of water vapour. The necessary corrections are derived for both an analyser fitted with selective filters and where the air is dried for use in leaf-chamber experiments, and also for measurements of absolute carbon dioxide concentrations and determinations of field profiles. The magnitudes of the corrections are determined for typical examples.

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1.12 STILES, W. (1970) A diffusive resistance porometer for field use. I. Construction. *J. appl. Ecol.* **7**, 617–622.

Details are given of the construction of a porometer to measure the stomatal resistance of leaf surfaces. The principle is the same as that used by van Bavel: water vapour from inside the leaf is allowed to diffuse into an initially dry cup clipped on to the leaf, and, after calibration, the surface resistance is estimated from the rate of increase of humidity in the cup. The humidity-sensing element is sulphonated polystyrene, and the possible wide variety in size gives latitude in the choice of cup dimensions and hence in the range of leaf sizes on which the equipment can be used.

Chemistry Department

THESIS

2.1 SIVASUBRAMANIAM, S. (1970) The role of aluminium ions in: I. The release of potassium from mineral soils, its modification by soil organic matter, and II. Its effect on the nutrient composition of tea (*Camellia Sinensis*). Ph.D. Thesis, University of London.

GENERAL PAPERS

2.2 BENZIAN, B. (1970) Nutrition of young conifers and soil fumigation. In: *Root diseases and soil-borne pathogens* (*Part Proceedings of the 1st International Congress of Plant Pathology, London, 1968*) Ed. T. A. Toussoun, *et al.* Berkeley and Los Angeles: University of California Press, pp. 222–225.

2.3 BENZIAN, B. & FREEMAN, S. C. R. (1970) Nursery and forest extension experiments in tree nutrition. Copper deficiency in conifer seedlings. Nitrogen concentrations in conifer transplants and subsequent growth in the forest. *Rep. Forest Res., Lond.*, 1970, pp. 168–170.

2.4 COOKE, G. W. (1969) Effects of cropping systems on soil productivity. *Report of 25th Ordinary Meeting, Central Association of Agricultural Valuers*, pp. 33–40.

2.5 COOKE, G. W. (1970) Using chemicals to increase soil productivity. In: *New horizons for chemistry and industry in the 1990s.* (*Proceedings of Symposium at Lancaster, July 1969*) London: Society of Chemical Industry, pp. 45–54.

2.6 COOKE, G. W. (1970) The carrying capacity of the land in the year 2000. In: *The optimum population for Britain.* (Institute of Biology Symposium No. 19) Ed. L. R. Taylor. London and New York: Academic Press, pp. 15–42.

2.7 COOKE, G. W. (1970) Soils and fertilisers. *Jl R. agric. Soc.* **131,** 107–128.

2.8 COOKE, G. W. (1970) Soil holds many answers to crop problems. *Eastern Daily Press Supplement*, May 5, 1970, Pt II.

2.9 COOKE, G. W. (1970) Fertilizers. *Encyclopaedia Americana.*

2.10 COOKE, G. W. (1970) Sir John Bennet Lawes. *Encyclopaedia Americana*, Vol. 17.

2.11 COOKE, G. W. & WILLIAMS, R. J. B. (1970) Losses of nitrogen and phosphorus from agricultural land. *Water treatment and examination*, **19**, 253–276.

2.12 GASSER, J. K. R. (1969) Available soil nitrogen—its measurement, and some factors affecting its correlation with crop performance. *Rep. Welsh Soils Discussion Group* No. 10, 76–92.

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2.13 GRAHAM-BRYCE, I. J. & BRIGGS, G. G. (1970) Pollution of soils. *R.I.C. Rev.* **3**, 87–104.

2.14 WIDDOWSON, F. V. (1971) Manuring potatoes. *Shellstar Agricultural Handbook—Potatoes.*

PAPERS IN ROTHAMSTED REPORT, PART 2

2.15 BOLTON, J. (1971) Long-term liming experiments at Rothamsted and Woburn. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 98–112.

This paper gives the results of two liming experiments started in 1962 and cropped with beans (3 years), spring barley (3 years) and potatoes. Effects of cumulative superphosphate and potassium chloride dressings on the crops at each level of liming are described.

2.16 WILLIAMS, R. J. B. (1971) Relationships between the composition of soils and physical measurements made on them. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 5–35.

Mechanical compositions, organic matter contents and histories of 189 soils, mostly British, were related to bulk densities, water-holding capacity, instabilities to slaking by water or mechanical pressure, and to breaking strengths of soil cylinders formed by pressure.

2.17 WILLIAMS, R. J. B. (1971) The chemical composition of water from land drains at Saxmundham and Woburn, and the influence of rainfall upon nutrient losses. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 36–67.

The concentrations of K, Ca, Mg, Na, NH_4-N, NO_3-N, PO_4-P, SO_4-S and Cl in samples of drainage from Saxmundham and Woburn Farms taken during two years are related to weather, drainage flows and fertiliser dressings. Nutrients in water on the surface of land, in a pond at Saxmundham, and in a stream and a lake at Woburn were also measured.

2.18 WILLIAMS, R. J. B. & COOKE, G. W. (1971) Results of the Rotation I Experiment at Saxmundham, 1964–69. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 68–97.

Yields, and nutrients removed by crops for 6 years, are recorded. The classical manuring was continued on full plots for 1964 and 1965 and then on small sub-plots. A new manuring scheme introduced on the main plots in 1966 is described and results given. The balance between nutrients applied in fertilisers and removed in crops is related to changes in the chemical compositions of the soils.

RESEARCH PAPERS

2.19 ADDISCOTT, T. M. (1970) A note on resolving soil cation exchange capacity into 'mineral' and 'organic' fractions. *J. agric. Sci., Camb.* **75**, 365–367.

'Mineral' and 'organic' fractions of soil cation exchange capacity (*CEC*) were resolved. 'Mineral + organic' *CEC* was measured by replacing Ba with Mg and pH 8·1 and determining loss of Mg from solution; 'mineral' *CEC* was measured by replacing Ca with K at the same pH and determining the loss of K from the solution. The difference between the two measurements (i.e. the 'organic' *CEC*) was related to percentage of organic C in some Rothamsted and Woburn arable soils; the relationship was good ($r^2 = 0{\cdot}90$) and the mean value of the *CEC* of organic matter in these soils was 230 me/100 g of organic matter.

2.20 ADDISCOTT, T. M. (1970) Potassium : calcium exchange in soils of the Broadbalk experiment at Rothamsted. *J. agric. Sci., Camb.* **75**, 451–457.

Soils from Broadbalk field were used to find whether differences in K-manuring had altered K : Ca exchange relationships during 100 years cropping with wheat, by measuring cation exchange capacities and quantity/intensity (Q/I) relationships.

Cation exchange capacities (*CEC*s) were measured with and without the contribution of the soil organic matter and the following mainly non-significant trends arose during 100 years:

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(1) the *CEC*s of plots given K fertiliser increased slightly when the organic contribution is included and decreased slightly when it is not; (2) the *CEC* of the plot given farmyard manure increased greatly when the organic contribution is included and decreased slightly when it is not; (3) the *CEC* of the unfertilised plots increased very slightly, whether or not the organic contribution is included.

The K buffer capacity, the slope of the Q/I curve when the soil neither gains nor loses K, was related to the K saturation of the *CEC* better when the organic contribution was omitted from the *CEC* than when it was included, suggesting that K : Ca exchange measured by the Q/I curves occurs mainly on the non-organic part of the *CEC*. Two soils depleted of K had anomalously large buffer capacities, but two undepleted samples behaved similarly.

Superimposing Q/I curves by eye showed no appreciable differences between samples from different years or from different plots, even at large activity ratios. Plotting exchangeable K against I_0, the activity ratio when the soil neither gains nor loses K, gave a single curve embracing all plots from all years, similar to the superimposed Q/I curves. Long-term manuring with ammonium sulphate has not affected K–Ca exchange.

2.21 ADDISCOTT, T. M. & MITCHELL, J. D. D. (1970) Potassium uptake by potatoes. *J. agric. Sci., Camb.* **74**, 495–500.

Potatoes (var. Pentland Dell) were grown in pots containing soils from the Rothamsted ley–arable experiments. When about half the initially available K was used, the tops were harvested and the potential limiting K uptake, inferred from K uptakes was −4150 cal/eq. The plants grew on until they exhausted the available K and died, having set tubers. The potential then limiting K uptake, inferred from total K uptakes, was −4900 cal/eq., similar to the mean potential in the exhausted soils, -4710 ± 61 cal/eq. The significance of these measurements is discussed.

Total K uptake was closely related to the amount of K that had to be removed from each soil to lower the potential to −4900 cal/eq. and the relationship suggested that the potatoes did not use any K from initially non-available reserves.

Dry-matter yields of tubers and tops + roots, and the ratio of the two, were well related to quantity and potential of K in the soil; tuber yield was also well related to K in tops. The K potential needed for maximum yield of tubers exceeded −2430 cal/eq.

2.22 BOLTON, J. & BENZIAN, B. (1970) Sulphur as a nutrient for Sitka spruce (*Picea sitchensis*) seedlings and radish (*Raphanus sativus*) grown on a sandy podzol in England. *J. agric. Sci., Camb.* **74**, 501–504.

Experiments with Sitka spruce (*Picea sitchensis*) seedlings grown on an acid sandy podzol at Wareham, Dorset, showed that sulphur fertilisers improved the colour but not the height of the crop and increased sulphur concentrations in the needles above those considered by Ingestad (1962) to indicate sulphur deficiency for Norway spruce (*Picea abies*). Spruce seedlings on other soils (Oxford and Woburn) contained more sulphur than at Wareham. Sulphur concentrations in most transplants of both species were less when S-free basal fertilisers were used.

Experiments with radish (*Raphanus sativus*) confirmed that Wareham soil is poor in available sulphur. Increased yields were obtained from elemental sulphur applied during the springs of 1968 and 1969, but not during the summers, when more sulphur may have been mineralised in the warmer soil. Wareham is in an area with less sulphur in the rain and atmosphere than most other parts of England.

2.23 BROMFIELD, A. R. (1969) Uptake of phosphorus and other nutrients by maize in Western Nigeria. *Expl Agric.* **5**, 91–100.

Uptake of the major nutrients by maize was determined throughout the growing season. Little phosphorus was accumulated, as reflected in its distribution within the plants, but uptake of labelled phosphorus showed two distinct peaks associated with root development. One-fifth of the applied phosphorus was recovered by the plants.

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2.24 CHATER, M. & GASSER, J. K. R. (1970) Effects of green manuring, farmyard manure, and straw on the organic matter of soil and of green manuring on available nitrogen. *J. Soil Sci.* **21**, 127–137.

In an experiment on green manuring started at Woburn in 1936, farmyard manure (FYM) was applied in alternate years until 1954 and straw similarly from then until 1963. Various green manures were grown from 1936 to 1953. From 1954 to 1963 ryegrass and trefoil were grown either each year or in alternate years; in 1964 and 1965 they were grown each year.

After annual cropping without organic manuring the organic-C and total-N decreased from 0·86% and 0·091% respectively in 1936 to 0·76% and 0·082% in 1966. Ploughing in straw alone approximately halved the loss. FYM and green manures both maintained the original percentages of soil C and N. The effect of FYM and straw applied together was approximately the sum of the effects of FYM and straw applied separately.

Of the green manures ploughed in, trefoil returned the most nitrogen to the soil.

Trefoil increased and ryegrass decreased the mineralisable-N in the soil.

2.25 ELSMERE, G. T. & RAWSON, R. A. G. (1970) A simple vacuum-gauge scale expander. *J. Phys.* E: *Sci. Instrum.* **3**, 1013–1014.

A Wheatstone bridge circuit is described that greatly expands any part of a conventional vacuum gauge scale. Used with an Edwards 'Pirani-type' gauge (range 0·1 m torr to 1 torr), the range 18–22 m torr, covering 0·5 cm of the Pirani scale, was expanded linearly to 16 cm.

2.26 GASSER, J. K. R. (1970) The decomposition of crotonylidene di-urea in soil and the recovery of nitrogen by ryegrass. *J. agric. Sci., Camb.* **74**, 107–110.

Crotonylidene di-urea (CD-urea) in a sandy-loam and two clay–loam soils decomposed slowly at 7°C, and from 8 to 15% was recovered as mineral-N after 24 weeks. At 25°C, it decomposed faster in the sandy-loam than the clay–loam soils; with 100 ppm N, a maximum of 86% was recovered after 16 weeks, and 80% of 1000 ppm N after 24 weeks. Recovery after 24 weeks ranged from 30 to 60% in the clay loams.

Ryegrass grown in pots produced more extra dry matter, containing more N, during 16 weeks when given ammonium sulphate than it did during 50 weeks with CD-urea.

2.27 HAMLYN, F. G. & GASSER, J. K. R. (1970) Some causes of error in determination of total nitrogen in plant material. *Chemy Ind.* 1142–1143.

Dried samples of nine plant materials ground to pass a 1·0 mm screen were sieved successively through a No. 16, 30 and 60 mesh sieve and the fractions weighed and analysed for N by a macro-Kjeldahl method. 'Stalky' crops, kale, clover, hay and young grass contained more coarse material than sugar beet tops, the grains of barley, oats or maize, and Sitka spruce seedlings. The coarsest fraction of all plant materials had least percentage N. The change between the other fractions varied with the crop.

Sub-samples of the 1 mm material were ground to pass a 0·25 mm sieve and percentage N in normally and finely ground materials was determined in 100 mg samples by an automatic Dumas method and by a micro-Kjeldahl method with 50 mg samples. All mean values determined by Kjeldahl method were less than those by Dumas and the general means differed significantly. Grinding samples more finely improved precision more with the Dumas than with the micro-Kjeldahl method.

2.28 HEINTZE, S. G. (1968) Manganese–phosphate reactions in aqueous systems and the effects of applications of monocalcium phosphate, on the availability of manganese to oats in an alkaline fen soil. *Pl. Soil* **29**, 407–423.

Electrometric titrations and chemical analyses of aqueous systems containing manganese sulphate and phosphoric acid showed that the compositions of manganese phosphates formed at various pH values depended on initial manganese concentrations and Mn : P molar ratios. The results show how phosphate benefits crops on soils containing toxic amounts of manganese.

A pot experiment measured the effects of monocalcium phosphate, with or without extra

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manganese, on the availability to oats of manganese in an alkaline manganese-deficient soil. On such a soil, phosphate equivalent to 750 or 1500 lb of superphosphate per acre is unlikely to enhance manganese availability; such dressings may lessen grain yields considerably.

Neutral and alkaline manganese-deficient fen soils were incubated with monocalcium-phosphate with and without added manganese salts. The phosphate dressings had only small effects on soil pH and on exchangeable and readily reducible manganese.

2.29 (ISLAM, A.) & BOLTON, J. (1970) Effects of pH on potassium intensity and release of non-exchangeable potassium to ryegrass. *J. agric. Sci., Camb.* **75**, 571–576.

More non-exchangeable K was removed by ryegrass from unlimed than limed soils but differences between pH 5·5 and 7·0 were small. Air-drying the soils after cropping released further exchangeable K in amounts independent of soil pH.

Potassium activity ratios after each cut declined to small constant values characteristic of the soils. After a few crops, the sandy soil (Woburn) released K faster than the soil with more clay (Sawyers) although initially it contained less exchangeable K.

2.30 MATTINGLY, G. E. G. (1970) Residual value of basic slag, Gafsa rock phosphate and superphosphate in a sandy podzol. *J. agric. Sci., Camb.* **75**, 413–418.

Surface soils (0–15 cm) from a field experiment on a sandy podzol were used to evaluate the residues from basic slag, Gafsa rock phosphate and superphosphate (using ryegrass in pots), and to measure the solubility and buffer capacity during cropping, and the distribution of the residual phosphate in different particle-size fractions of the soil.

After applying P at about 3·6 g P/m²/year for 6 years, residues of the three P fertilisers were equivalent but after applying more P (9–11 g P/m²/year) for a further 8 years, basic slag and rock phosphate gave larger labile P values, were more effective for ryegrass and buffered soils more than residues of superphosphate. The percentage recoveries of P from the surface soils were approximately 7, 40 and 65% of the total applied in 8 years as superphosphate, basic slag and rock phosphate respectively.

Residues from basic slag (mainly 75–20 μm particles) accumulated in the <20 μm fraction of the soil. Rock phosphate (mainly 200–20 μm particles) dissolved more slowly and about one-half of the material >20 μm remained in the sand fractions of the soil.

Residues from rock phosphate maintained values of $\frac{1}{2}pCa + pH_2PO_4$ and $pH - \frac{1}{2}pCa$ consistent with the solubility of fluorapatite, even when P was removed from the soil by exhaustive cropping with ryegrass. Residues from basic slag were more soluble than hydroxyapatite.

2.31 MITCHELL, J. D. D. (1970) Yields of, and N uptakes by, some grass species and varieties under different glasshouse conditions. *J. agric. Sci., Camb.* **75**, 361–363.

The amount of dry matter produced and N taken up by seven grass species and varieties grown in a glasshouse were compared with perennial ryegrass (S.23) and Italian ryegrass (S.22) at different day-lengths and light intensities.

The ryegrasses Westerwolds, Italian (S.22) and Perennial (S.321) yielded more than S.23. At the smallest light intensities, Westerwolds, Italian (S.22) and Perennial (S.24) (S.321) ryegrasses and Meadow fescue (S.215) took up more N than S.23. Westerwolds and Perennial (S.24) (S.321) ryegrasses should be useful alternatives to the S.23 or S.22 strains as test crops in nutrient experiments in the glasshouse, especially when grown in the dim light during winter.

2.32 SPRATT, E. D. & GASSER, J. K. R. (1970) The effect of ammonium sulphate treated with a nitrification inhibitor, and calcium nitrate, on growth and N-uptake of spring wheat, ryegrass and kale. *J. agric. Sci., Camb.* **74**, 111–117.

Wheat, ryegrass and kale were grown with ammonium sulphate (treated with a nitrification inhibitor) or calcium nitrate supplying 50 and 100 lb N/acre, and without fertiliser-N. Plants were sampled at various stages, dry weights measured, percentage N determined and N uptakes calculated.

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Initially wheat and ryegrass grew better and took up more N from ammonium fertiliser than from nitrate. Final yields of dry matter did not differ between forms. Kale produced more dry matter with calcium nitrate than with ammonium sulphate. All crops produced more dry matter with fertiliser-N than without. Fertilised crops contained greatest weights of N 109 days after sowing, when wheat and ryegrass had more with ammonium than with nitrate and kale had less. The 50 lb N/acre as calcium nitrate produced the most wheat grain/lb of fertiliser-N.

During the period when growth and N uptake were fastest, wheat grew faster with ammonium than with nitrate, ryegrass grew similarly with both forms, and kale faster with nitrate; wheat and ryegrass took up N faster from ammonium sulphate and kale from calcium nitrate.

Mature wheat recovered 58% of the fertiliser-N from calcium nitrate and 43% from ammonium sulphate. After 21 weeks of growth, kale recovered more N from calcium nitrate (50%) than from ammonium sulphate (24%), whereas grass recovered about 40% from each.

2.33 SPRATT, E. D. & GASSER, J. K. R. (1970) The effects of fertiliser-N and water supply on distribution of dry matter and N between the different parts of wheat. *Can. J. Pl. Sci.* **50,** 613–625.

Wheat in pots and in the field were subjected to different watering regimes and fertiliser-N either as ammonium-N with a nitrification inhibitor or as nitrate-N, applied at sowing or during growth.

More leaves and stems were produced during early growth with ammonium than with nitrate-N, but the two forms gave similar yields of grain. The grain : straw ratio with ammonium-N was smaller than with nitrate-N and more N was retained in the straw. Each form increased the weight per spike but not the number of spikes per unit area (tillering).

Applied at the 'boot' stage of growth, N increased dry matter much less than when applied at sowing, but increased %N in the grain. Divided dressings, half at sowing and half during growth, increased yield and N uptake by the same amount as applying all the N at sowing.

Drought during spike formation or floret development led to smaller spikes and yields of grain; also a smaller grain : straw ratio, and up to three-quarters of the extra N taken up from fertiliser-N remained in the straw.

2.34 SPRATT, E. D. & GASSER, J. K. R. (1970) The effect of ammonium and nitrate forms of N and restricted water supply on growth and N uptake of wheat. *Can. J. Soil Sci.* **50,** 263–273.

Wheat was grown with fertiliser-N, either as ammonium sulphate (treated with a nitrification inhibitor) or as calcium nitrate, and without fertiliser-N and with various water treatments, both in the field and in pots in the glasshouse. With adequate water, wheat produced the most dry matter (and grain) containing the most N when supplied with nitrate; when shortage of water limited growth, ammonium-N was as good, or better, than nitrate-N for increasing dry matter production and N uptake. From stem extension to flowering, the leaves and stems contained twice as much NO_3-N when given nitrate-N as when given ammonium-N.

2.35 VAIDYANATHAN, L. V. & TALIBUDEEN, O. (1970) Rate processes in the desorption of phosphate from soils by ion-exchange resins. *J. Soil Sci.* **21,** 173–183.

Phosphate extracted by ion-exchange resins in the chloride and sodium forms from a deep river-gravel soil under widely varying conditions is always from the isotopically exchangeable or 'labile' pool. At any reaction time, a constant fraction of this pool is desorbed by the chloride form of the anion-exchange resin alone, irrespective of the pH and phosphate manuring of the soil. However, when a sodium : cation exchange resin is included, increasing fractions of the 'labile pool' are desorbed with decreasing soil acidity.

Phosphate desorption by the anion-exchange resin alone and with the cation exchange resin is shown to be 'particle-diffusion' controlled in the anion exchange resin and neither a 'chemical reaction' nor a 'film-diffusion' mechanism. Over the pH range 4·5–8·5, values between 4·8 and $0{\cdot}9 \times 10^{-9}$ cm^2 sec^{-1} were calculated for the inter-diffusion coefficient of the phosphate : chloride exchange process in the resin.

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The isotopically exchangeable phosphate in the soils seems to behave as sparingly soluble or weakly dissociating compounds towards ion-exchange resins and its rate of desorption depends on the nature and composition of the resins.

2.36 WEBBER, M. D. & MATTINGLY, G. E. G. (1970) Inorganic soil phosphorus. I. Changes in monocalcium phosphate potentials on cropping. *J. Soil Sci.* **21**, 111–120.

Sixteen soils and four soil preparations were cropped exhaustively with ryegrass in the glasshouse and monocalcium phosphate potentials ($\frac{1}{2}$pCa + $pH_2PO_4 = I$) measured after each of six consecutive harvests. The amounts of phosphorus (Q) removed from the soils by ryegrass accounted for 95·1–96·6% of the variance in I for three soils and two soil preparations ($P < 0{\cdot}001$), for 88·4–93·7% of the variance for six soils and two soil preparations ($0{\cdot}001 < P < 0{\cdot}01$), for 71·6–82·6% of the variance for three soils ($0{\cdot}01 < P < 0{\cdot}05$) and for insignificant amounts of the variance for four soils. Values of $\Delta I/\Delta Q$ ranged from 7×10^{-4} to 431×10^{-4} $\frac{1}{2}$pCa + pH_2PO_4/ppm P removed from soil.

$\Delta I/\Delta Q$ tended to decrease (i.e. the soils were more buffered) with increasing clay contents and with increasing amounts of $NaHCO_3$-soluble P and to increase (i.e. the soils were less buffered) with increasing amounts of $CaCO_3$. Differences in organic C did not significantly affect $\Delta I/\Delta Q$. The following equation accounts for 81% of the variance in $\Delta I/\Delta Q$ for all soils except those in equilibrium with octacalcium phosphate:

$$\Delta I/\Delta Q \times (10^4) = 225{\cdot}9 - 4{\cdot}17\ (\%\ \text{clay}) + 8{\cdot}01\ (\%\ CaCO_3) - 1{\cdot}38\ (\text{ppm } NaHCO_3\text{-soluble P}).$$

2.37 WEBBER, M. D. & MATTINGLY, G. E. G. (1970) Inorganic soil phosphorus. II. Changes in monocalcium phosphate and lime potentials on mixing and liming soils. *J. Soil Sci.* **21**, 121–126.

Mixtures of Woburn (non-calcareous) and Barnfield (calcareous) soils, with and without added monocalcium phosphate, and of Woburn soil with added $CaCO_3$, were stored moist in an incubator at 25 ± 2°C. Equilibrium phosphate concentrations in 0·01M $CaCl_2$ and pH were measured on moist soils and monocalcium phosphate ($\frac{1}{2}$pCa + pH_2PO_4) and lime (pH − $\frac{1}{2}$pCa) potentials were calculated at intervals up to 670 days. Most of the mixtures remained undersaturated with respect to $CaCO_3$; values of $\frac{1}{2}$pCa + pH_2PO_4 and pH − $\frac{1}{2}$pCa changed during storage but remained close to the solubility isotherm for octacalcium phosphate (OCP). Mixtures which reached equilibrium with $CaCO_3$ remained undersaturated with respect to OCP.

2.38 WIDDOWSON, F. V. & PENNY, A. (1970) The effects of three crops and of the N fertiliser given to them on the yield of following barley. *J. agric. Sci., Camb.* **74**, 511–522.

In 1964 spring wheat and kale each were grown with 0·0, 0·5, 1·0 or 1·5 cwt N/acre. In 1965 barley measured residues. Without N and with 0·33 cwt N/acre the barley yielded more after wheat than after kale, but, with 0·66 or 1·0 cwt N/acre, more after kale. The residues of the N given for the wheat and kale increased barley yields.

In 1965 spring wheat, kale and Italian ryegrass each were grown with 0·0, 1·0 or 2·0 cwt N/acre. In 1966 and 1967 barley tested 0·0, 0·5 or 1·0 cwt N/acre in all combinations with previous treatments. In 1966 yields were largest after kale and smallest after ryegrass. Differences from the three crops were diminished by the N applied for them, and these N residues consistently increased yields. N given to the barley greatly increased yields, most after ryegrass and least after kale, and equally with or without fertiliser residues, but did not change differences from the crops. In 1967 yields were largest after ryegrass, but no larger after kale than after wheat. The residues of the N given for ryegrass increased yields. N given to the barley increased yields greatly, but most after kale.

In 1966 spring wheat, kale and Italian ryegrass each were grown without N and with 1·0 or 2·0 cwt N/acre, but on a more fertile field. In 1967 and 1968 barley tested 0·0, 0·5 or 1·0 cwt N/acre in all combinations with previous treatments. In 1967 yields were largest after kale and smallest after ryegrass. The residues of the N given in 1966 consistently increased yields when the

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barley was not given N, and after ryegrass when it was; but they decreased yields when N was given after wheat and kale. The barley needed 1·0 cwt N/acre after ryegrass, but less than 0·5 cwt N/acre after wheat or kale. In 1968 barley yielded most when it was not given N and then the largest yields were after ryegrass. The N given for the barley greatly decreased yields and the N residues decreased them further.

The amounts of N removed in the barley grain were well correlated with yields.

Pedology Department

Thesis

3.1 Williams, C. (1970) Biogeochemical factors influencing plant uptake of molybdenum and selenium. M.Phil. Thesis, University of London.

General Paper

3.2 Jenkinson, D. S. (1971) Studies on the decomposition of C^{14} labelled organic matter in soil. *Soil Sci.* **111**, 64–70.

Paper in Rothamsted Report, Part 2

3.3 Jenkinson, D. S. (1971) The accumulation of organic matter in soil left uncultivated. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 113–137.

The accumulation of soil organic carbon, nitrogen, sulphur and phosphorus was measured in three sites not cultivated since 1883. The sites had previously been arable for centuries, and are within 1·3 km of each other on the same soil series. Two had once been chalked and are still calcareous; in the third the pH, 7·1 in 1883, was 4·5 in 1965. The non-calcareous site and one of the calcareous sites have been undisturbed and are now deciduous woodland. Tree seedlings are regularly removed from the other calcareous site by stubbing.

Despite completely different vegetation, the soils of the calcareous stubbed and wooded sites have gained similar amounts of organic carbon, nitrogen, sulphur and phosphorus. In contrast, organic carbon, nitrogen, sulphur and phosphorus have all accumulated more slowly in the non-calcareous than in the calcareous wooded site. The wooded non-calcareous site gained 23 kg nitrogen per hectare per year during a period of 82 years (15 kg in the soil to a depth of 68·6 cm, plus an estimated 8 kg in the trees). In 81 years the stubbed site gained 55 kg nitrogen per hectare per year (all in the soil), the wooded calcareous site 65 kg, 53 in the soil and an estimated 12 kg in the trees. These differences between the sites are attributed to the increasing acidity of the non-calcareous soil. Little of the nitrogen gained by the two wooded sites can have been fixed in symbiosis with legumes, as these have long been absent from both sites.

Research Papers

3.4 Bloomfield, C., Brown, G. & Catt, J. A. (1970) The distribution of sulphur in the mud of Lake Victoria. *Pl. Soil*, **33**, 479–481.

Re-examination of mud from Lake Victoria showed the presence of pyrite. It has been claimed that these muds contain abnormally large amounts of organic sulphur, but pyritic and organic sulphur would not be distinguished by the method that was used. The organic sulphur content of the mud is therefore much less than previously reported, and there seems no reason to assume the presence of unusual organic sulphur compounds.

3.5 Bloomfield, C., Kelso, W. I. & Piotrowska, M. (1971) The mobilisation of trace elements by aerobically decomposing plant material under simulated soil conditions. *Chemy. Ind.*, 59–61.

The rates were measured at which the oxides of Fe, Mn, Zn, Co, Ni, Pb and Cu are dissolved by aerobically decomposing plant matter. Fe and Mn are relatively inactive. The first month of incubation was the period of most active mobilisation. The amount of dissolved Cu decreased

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sharply during the second month's incubation, while the Cu content of the insoluble organic residue increased correspondingly.

The capacity of the soluble organic decomposition products to dissolve the various oxides under sterile conditions decreases as rotting proceeds, except with Cu, with which the activity of the extracts increases at first and then decreases rapidly. Significant amounts of metal are fixed by the insoluble organic residues.

3.6 BROWN, G., CATT, J. A., (HOLLYER, S. E. & OLLIER, C. D.) (1969) Partial silicification of chalk fossils from The Chilterns. *Geol. Mag.* **106**, 583–586.

The calcite of brachiopod, lamellibranch and echinoid shells from the Upper and Middle Chalk of Hertfordshire and Bedfordshire is partly replaced by chalcedonic silica. The crystallographic forms of the silica are described, and its diagenetic emplacement inferred from thin section studies.

3.7 BROWN, G. & NEWMAN, A. C. D. (1970) Cation exchange properties of micas. III. Release of potassium sorbed by potassium-depleted micas. *Clay Min.* **8**, 273–278.

Two phlogopites depleted of potassium by extraction with sodium tetraphenyl boron released resorbed potassium more readily than the original micas, but the large differences in the exchange parameters of the two micas were paralleled by those of their potassium-saturated alteration products. The apparent basal spacings of the potassium-saturated alteration products were about 0·03 Å larger than those of the corresponding untreated micas; their broader lines indicate structural irregularities.

3.8 GREENE-KELLY, R. (1970) Optical properties of organic complexes of montmorillonite. *Clay Min.* **8**, 405–419.

The optical properties of oriented montmorillonite aggregates were measured in both non-complexing and complexing media. The changes observed lead to the following conclusions:

Preparing oriented aggregates of clays for optical examination requires considerable care to avoid spurious orientation effects.

In determining the optical constants of montmorillonite aggregates the medium must wet and enter the aggregate readily and displace the air, especially from the smaller pores, to avoid large form birefringence effects of uncertain magnitude. A suitable medium is likely to be one that will complex montmorillonite. The complex it forms must have relatively isotropic interlamellar layers, a state more probable with isodimensional molecules. Consideration of complexes with simple compounds suggests that the intrinsic birefringence of aggregates is over-estimated by conventional techniques.

Forming complexes with aromatic compounds usually results in the birefringence of the aggregate being essentially determined by the orientation and anisotropy of the intercalated molecules.

3.9 GREENE-KELLY, R. (1971) The shrinkage of clay soils during impregnation by polyethylene glycols. *J. Soil. Sci.* **22**. (In the press.)

Linear measurements on a remoulded clay soil showed that replacing pore water by molten polyethylene glycol 6000 (PEG 6000) was the main cause of the sample contracting. Subsequent cooling of the wax resulted in only a small further shrinkage. The volumetric shrinkage of different clay soils on impregnation with PEG 6000 was about one-half to three-quarters that on air-drying. The contraction increased with increasing average molecular weight of the PEG fraction. Exchange of pore water with digol, $O(CH_2CH_2OH)_2$, before impregnation with PEG 6000 decreased the total shrinkage by a further one-third.

3.10 JENKINSON, D. S. & POWLSON, D. S. (1970) Residual effects of soil fumigation on soil respiration and mineralisation. *Soil Biol. Biochem.* **2**, 99–108.

Soils were taken from fields that had been fumigated with formalin or methyl bromide 6 months to 5½ years previously. Fumigated and unfumigated soil respired at similar rates when incubated

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in the laboratory. In contrast, after exposure to chloroform vapour the fumigated soil respired less rapidly and mineralised less nitrogen than the unfumigated soil. Irradiation (2·5 Mrad) was broadly similar to chloroform vapour in its effects on soil respiration and mineralisation. These results are attributed to the elimination of a section of the soil biomass during field fumigation; recovery was not complete even after several years.

Field experiments sometimes show a declining crop response to repeated fumigation. Our results show that less nitrogen is mineralised after a second fumigation than after the first. Thus, when nitrogen is limiting growth, a second fumigation will be less effective than the first, quite apart from any effect on plant pathogens.

3.11 KING, H. G. C. & PRUDEN, G. (1970) Lower limits of molecular weights of compounds excluded from Sephadez G-25 eluted with aqueous acetone mixtures. *J. Chromat.* **52**, 285–290.

Compounds of molecular weight greater than 900, 500 and 300 are excluded from Sephadex G-25 eluted with 40, 50 and 60% aqueous acetone respectively. The lower exclusion limits were tested by showing that 40%, but not 50 or 60% aqueous acetone, separates the four phenolic components of tannic acid.

3.12 NEWMAN, A. C. D. (1970) Cation exchange properties of micas. II. Hysteresis and irreversibility during potassium exchange. *Clay Min.* **8**, 267–272.

The sorption of potassium by mica partially depleted of potassium was studied by adding potassium to a solution of sodium chloride in quasi-equilibrium with the mica. The concentration of potassium in the solution was increased 1·5 times before reverse exchange was initiated. Potassium resorbed by the depleted mica was extracted more readily than potassium from the original mica. Potassium exchange from mica is not reversible; there is irreversible change in the mica when potassium is exchanged, and also an additional hysteresis in the forward and reverse exchange.

3.13 NEWMAN, A. C. D. (1970) The synergetic effect of hydrogen ions on the cation exchange of potassium in micas. *Clay Min.* **8**, 361–373.

Interlayer K in 11 trioctahedral micas, with compositions ranging from fluorphlogopite to biotite, was replaced by treating cut flakes with aqueous solutions of Na salts at controlled pH values. Replacement in natural micas was faster at pH 4·5 than at pH 9 and there is a co-operative action, or synergy, of H^+ and Na^+ in replacing K^+. The synergetic effect of H^+ tends to be greatest in micas that lose most net negative charge when K is replaced, and increases when Fe^{2+} in biotite is oxidised by heating. Possible relationships between synergetic effect and the chemical composition of micas are discussed in relation to the structure and chemical changes in the aluminosilicate layers when K is exchanged, and it is concluded that incorporation of protons into the structure is responsible for the synergetic effect.

3.14 POWLSON, D. S. & JENKINSON, D. S. (1970) Inhibition of nitrification in soil by carbon disulphide from rubber bungs. *Soil Biol. Biochem.* **3**. (In the press.)

Some rubber bungs evolve enough carbon disulphide to inhibit organisms that convert ammonium to nitrite in soil; 0·5 ppm carbon disulphide decreased nitrification in one soil by 80% and 8 ppm stopped it completely.

3.15 WEIR, A. H., CATT, J. A. & MADGETT, P. A. (1971) Post-glacial soil formation in the loess of Pegwell Bay, Kent (England). *Geoderma* **5**, 131–149.

The mineralogy, micromorphology and particle size distribution of seven horizons in a buried soil developed in Weichselian loess at Pegwell Bay in south-east England are described. The radiocarbon date of the soil organic matter is 6120 ± 250 years B.P., and the profile was buried by colluvium in late prehistoric times. Most of the profile development probably occurred in a few thousand years, mainly during the Post-glacial climatic optimum. The composition of sand (>50 μm) and silt (2–50 μm) fractions suggests that only 10–20% of the loess was derived from

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the local Thanet Beds (Palaeogene). The remainder is mineralogically similar to loess in other parts of south and east England, and is probably far-travelled.

After decalcification of the loess, the main soil-forming process was translocation of fine and medium clay (<0·5 μm) from the upper 450 mm of the profile into lower horizons. However, the horizons of clay accumulation contain more fine clay (<0·1 μm) than could have been derived from the upper 450 mm. This apparent gain of fine clay results partly from the weathering of glauconite in the highest 450 mm of the profile.

Soil Microbiology Department

General Papers

4.1 Nutman, P. S. (1971) Perspectives in biological nitrogen fixation. *Sci. Prog.* **59**, 55–74.

4.2–4.5 Nutman, P. S. (1971) 1. Ecology of *Rhizobium* in soil. 2. Physiology of root hair infection. 3. Physiology of nodule formation. 4. Genetics of legume nodulation. *Proc. V Reinião Latino-Americana de Rhizobium, Rio de Janeiro, Brazil.* (In the press.)

4.6 Skinner, F. A. (1969) Microbiology of the soil. *Rep. Prog. appl. Chem.* **54**, 375–390.

4.7 Skinner, F. A. (1970) Microbial heterogeneity of soil. *Rep. Welsh Soils Discussion Group.* (In the press.)

4.8 Skinner, F. A. (1971) The isolation of soil clostridia. In: *The isolation of anaerobic organisms. Society for Applied Bacteriology Technical Series* No. 5, pp. 57–80. London: Academic Press.

Research Papers

4.9 Bell, F. & Nutman, P. S. (1971) Experiments on nitrogen fixation by nodulated lucerne. *Pl. Soil.* (In the press).

Field experiments at five sites compared dry-matter yields and nitrogen contents of lucerne and ryegrass. These tested Rhizobium inoculation and fertiliser treatments in an experimental design proposed by Vincent and Nutman IBP 69(66), amended 57/68. Estimates of fixation ranged from 0 to more than 300 kg N ha^{-1} at the different sites, and treatment comparisons indicated the main factors limiting fixation. Parallel experiments using a soil core technique described by Vincent gave very similar results to the field trials in their first year.

4.10 Brown, M. E. & Hornby, D. (1971) Behaviour of *Ophiobolus graminis* on slides buried in soil in the presence or absence of wheat seedlings. *Trans. Br. Mycol. Soc.* **56**, 95–103

On slides buried in field soils, mycelial inoculum of *Ophiobolus graminis* produced hyphae, which grew towards wheat seedling roots, forming clumps of cells in the root hair region and infecting hairs before penetrating seminal root axes. Without roots new hyphae grew, but phialospores (microconidia) were produced abundantly. Growth was similar using infected wheat roots as inoculum, except fewer and smaller clumps developed. Using infested debris from a wheat field as inoculum, the amount of clump formation and root hair infection was negatively correlated with the size of the colonised host fragments and no phialospores developed. All clumps were ephemeral and lysed quickly after seminal axes were infected. Phialospores remained intact during 21 days observation, but did not germinate. Mycelium labelled with fluorescent brightener confirmed that the observed growths were *O. graminis*.

It is suggested that *O. graminis* has an ephemeral feeding stage before initial infection of an

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axis. The extent of this depends on the nutritional status of the original inoculum; inoculum with large food reserves can infect roots without extensive clump development and root hair infection. When there is no host stimulus, active mycelium with small food reserves produces phialospores, but slowly metabolising mycelium in debris does not.

4.11 DART, P. J. (1971) Scanning electron microscopy of plant roots. *J. exp. Bot.* **22**, 163–168.

A glycol methacrylate infiltration and polymerisation technique was used to prepare clover roots inoculated with *Rhizobium* for scanning reflection electron microscopy. Root hairs and epidermal cells were coated with many bacteria; some bacteria seemed to be embedded in the wall surface. Root hair tips were often smooth but some older root hair surfaces showed a fibrillar meshwork pattern. Small granules *c.* 0·18 μm diameter were present on the root hair and epidermal cell walls. The root cap, some root hairs, and some epidermal cells were covered by an amorphous film thought to be the mucigel.

4.12 DART, P. J. & DAY, J. M. (1971) Effects of incubation temperature and oxygen tension on nitrogenase activity of legume root nodules. *Pl. Soil.* (In the press.)

Acetylene reduction and H_2 evolution by legume root nodules from several plant species depended on incubation temperature; some nodules were active from 2–40°C. Acetylene reduction rates differed between plant species, with maximum activity at temperatures between 20° and 30°C for *Vicia faba*, *V. sativa*, *Trifolium pratense*, *T. subterraneum*, *Medicago truncatula* and *Glycine max*, at 35°C for *M. sativa* and 40°C for *Vigna sinensis*. Only *M. sativa* and *Vigna sinensis* reduced substantial amounts at 37·5°C. Temperatures from 2°–10°C only slightly lessened activity of *T. subterraneum* and *V. sativa* nodules. Nitrogenase functioned at temperatures which prevent establishment of other aspects of the symbiosis. Acetylene was reduced at a constant rate for several hours at temperatures below 15°C, and activity continued for several days at 2°C in some species, but declined with time at warmer temperatures. Some nitrogenase was denatured at warmer temperatures, but the O_2 tension in the assay vial also affected activity. In closed assay vials nodule respiration decreased the pO_2 and reduced nitrogenase activity. Activity was restored by adding O_2 or regassing assay vials with air or Ar : O_2. When the O_2 was maintained, acetylene reduction and H_2 evolution by detached soyabean nodules continued unchanged for 6 hours.

4.13 GRIFFITHS, D. C. & WALKER, N. (1970) Microbiological degradation of parathion. *Meded. Faculteit Landbouw-Wetenschaffen Gent.* **35**, 805–810.

Soil percolation experiments showed that parathion (diethyl-4-nitrophenyl phosphorothionate) was decomposed in soil by a heat-labile agent, transferable in small amounts from one soil culture to another. This is consistent with the effects of microorganisms, but the responsible organisms have not yet been isolated in pure culture. Microrespirometer experiments showed that soil pseudomonads, which grew with 4-nitrophenol as their sole carbon source, did not metabolise parathion.

4.14 HAYMAN, D. S. & MOSSE, B. (1971) Plant growth responses to vesicular–arbuscular mycorrhiza. I. Growth of *Endogone*-inoculated plants in phosphate-deficient soils. *New Phytol.* **70**, 19–26.

Onion and *Coprosma* plants were grown in a range of soils mostly containing very little available phosphate. Very large increases of shoot dry-weight (up to 18-fold with *Coprosma* and 19-fold with onion) were obtained by adding phosphate. Similar increases (up to 15-fold with *Coprosma* and 12-fold with onion) were obtained by mycorrhizal inoculation. The response to phosphate equalled or slightly exceeded the response to mycorrhiza, except in two soils rich in phosphate in which there was no response to either, and in one soil in which the mycorrhizal onion and *Coprosma* plants were twice as heavy as those given phosphate. The greatly increased growth from either treatment was associated with a large increase in the uptake of phosphorus. The

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probability of such growth responses, but not their size, was usually predictable in soils containing very little phosphorus soluble in $CaCl_2$. In all soils with inoculum mycorrhizal infection was extensive. The sources of phosphorus available to mycorrhizal roots but not to non-mycorrhizal roots differed in the various soils. In some, inhibitory factors might make vesicular–arbuscular mycorrhiza less effective in promoting the growth of the host plants.

4.15 KLECZSKOWSKA, J. (1971) Genetical changes in *Rhizobium* bacteria and in their bacteriophages during coexistence. *Pl. Soil.* (In the press.)

Three systems, each consisting of a virulent phage and a susceptible bacteria, were incubated for 24 weeks in liquid culture and the processes of interaction and genetical change in both partners investigated. The initial stage of interaction in all systems was identical; all susceptible bacterial cells were lysed and only cells that originally were resistant or mutated to resistance, remained alive. In two systems the multiplication of resistant cells was not restricted by large concentrations of phage; in the third bacteria did not multiply. Phage concentration was maintained at a high titre for the duration of the experiment by presence of the resistant mutant bacteria. Phage resistant mutants were genetically less stable than the parent forms; some also had changed colony morphology and symbiotic properties. Mutations in these different characteristics were independent. In two systems, virulent phage mutated into temperate form; hence some of the phage-resistant mutant cells were genetically suitable to establish lysogeny.

4.16 MOSSE, B. & HAYMAN, D. S. (1971) Plant growth responses to vesicular–arbuscular mycorrhiza. II. In unsterilised field soils. *New Phytol.* **70**, 27–34.

The benefits of mycorrhizal infection were compared in four irradiated and unsterilised soils containing little soluble phosphorus. Mycorrhizal infection was produced in onion seedlings by pre-planting in a heavily infected soil and transplanting into the test soil, or by sowing *in situ* on a cushion of *Endogone* inoculum. In all soils, irradiated or not, mycorrhizal seedlings grew very much better than non-mycorrhizal ones. In two of the soils natural infections were few and most uninoculated seedlings remained non-mycorrhizal even after 16 weeks. In the other two soils most plants became mycorrhizal in the unsterilised soils. In one of them, the indigenous mycorrhizal fungi aided phosphorus uptake by the host plant, in the other they did not. Infections produced by the indigenous fungi in the two soils were anatomically different, though both were typical vesicular–arbuscular mycorrhiza.

It is concluded that inoculation may have practical significance in some soils poor in phosphate and containing either few indigenous mycorrhizal fungi or ineffective strains.

4.17 NUTMAN, P. S., MARECKOVÁ, H. & RAICHEVA, L. (1971) Selection for increased nitrogen fixation in red clover. *Pl. Soil.* (In the press.)

Plants were selected and bred from the modal yield class of the population and from the class showing the largest yield (and nitrogen content), under conditions of test-tube culture using a single strain of rhizobia as inoculum. Progeny tests made on about 60 crosses within each group over two generations showed larger yields in families raised from the most effective parent plants, but the average effect of selection was small (about 5% dry weight increase). When the same material was tested with other strains of bacteria the effect of selection was smaller or disappeared, and when uninoculated plants were given nitrate the effect of selection was also less, but did not entirely disappear. In these conditions, selection was partly for increased symbiotic nitrogen fixation and partly for tolerance of the restricted conditions of growth.

4.18 NUTMAN, P. S., ROUGHLEY, R. J., DART, P. J. & SUBBA-RAO, N. S. (1970) Effect of low temperature pre-treatment on infection of clover root hairs by *Rhizobium*. *Pl. Soil* **33**, 257–259.

Holding 24-hour seedlings of *Trifolium* spp. at 3°C increased the number of root hairs infected by *Rhizobium* when the plants were subsequently inoculated and grown at 19°C. This effect was transitory, disappearing on plants more than 7 days old.

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4.19 PHILLIPS, J. M. & HAYMAN, D. S. (1970) Improved procedures for clearing roots and staining parasitic and vesicular–arbuscular mycorrhizal fungi for rapid assessment of infection. *Trans. Br. mycol. Soc.* **55**, 158–161.

Fungal infections in whole non-pigmented roots were strongly stained with 0·05% trypan blue after clearing the host tissues in hot KOH. With pigmented roots a longer clearing time in KOH, followed by bleaching in alkaline H_2O_2 before staining, also revealed intensely stained fungal structures.

Botany Department

GENERAL PAPERS

5.1 (MOORE, F. J. H.) & THURSTON, J. M. (1971) Interrelationships of fungi, weeds, crops and herbicides. *Proc. 10th British Weed Control Conference*, 1970, **3**, 920–926.

5.2 THORNE, G. N. (1971) Physiological factors limiting yield of cereal crops. In symposium on: *Potential crop production in Britain*, Aberystwyth, 1969. Heinemann Educational Books Ltd., pp. 143–158.

5.3 WATSON, D. J. (1971) Size, structure and activity of the productive system of crops. In symposium on: *Potential crop production in Britain*, Aberystwyth, 1969. Heinemann Educational Books Ltd., pp. 76–88.

5.4 WILLIAMS, E. D. & (ATTWOOD, P. J.) (1970) Seed production by couch grass (*Agropyron repens*). *N.A.A.S. q. Rev.* No. 89, 42–46.

RESEARCH PAPERS

5.5 LOACH, K. (1970) Analysis of differences in yield between six sugar-beet varieties. *Ann. appl. Biol.* **66**, 217–223.

The basis of differences in yield between six sugar-beet varieties was studied by measuring the changes in their leaf areas and dry weights throughout the season. Initially, dry-matter production was determined by the rate at which leaf area developed, but this effect did not persist to final harvest. Varieties that maintained the largest net assimilation rates in September produced larger sugar yields. Characteristically, these varieties showed the smallest losses in lamina dry weight through leaf senescence late in the season, and put the largest proportion of their photosynthate into root production.

5.6 MILFORD, G. F. & WATSON, D. J. (1971) The effect of nitrogen on the growth and sugar content of sugar beet. *Ann. Bot.* **35**, 287–300.

Nitrogen fertiliser applied to sugar beet increased plant and root dry weight and leaf area, and decreased the sugar content of the root per cent of both fresh and dry weight. Change in leaf area accounted wholly for the increase in plant dry weight produced by nitrogen, because net assimilation rate was unaffected. Nitrogen did not alter the partition of the total assimilate between roots and shoots, but increased the fraction of total assimilate entering the roots that was used in growth, at the expense of that stored as sugar. Thus, plants with more nitrogen had a smaller proportion of their root dry weight as sugar because more was metabolised in growth of the roots, and not because less entered the roots.

The heavier roots of plants given more nitrogen were larger in cross-sectional area because the areas of both parenchyma and vascular zones of each peripheral ring within the root were larger; the number of rings was not increased. Nitrogen increased the areas of the tissues in these zones by enlarging cell volumes, not by increasing the number of cells within the tissues. Increase in cell volume was accompanied by proportional increases in the weights of non-sugar dry matter per cell and water per cell, but the amount of sugar per cell was proportional to cell volume only during the initial stage of cell expansion up to cell volumes of about 15×10^{-8} cm^3; there-

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after it was less than proportional, so that sugar per cent of both fresh and dry weight decreased as cell size increased beyond 15×10^{-8} cm^3. The relation of sugar per cell to cell volume was the same with both amounts of nitrogen given. This implies that increase in nitrogen supply made the sugar concentration of the root less by increasing the size of the root cells, and not by a specific effect on sugar storage.

5.7 THORNE, G. N. (1970) Use of controlled environments for studying the effects of climatic factors on growth and yield. In: *Prediction and measurement of photosynthetic productivity*. (Proc. IBP/PP Technical meeting, Třeboň, September, 1969.) Wageningen: Centre for Agricultural Publishing and Documentation (Pudoc), pp. 399–404.

Controlled environment facilities such as growth rooms or cabinets in which daylength, light intensity, temperature and humidity can be controlled can be used to distinguish between the effects of environmental factors that are closely correlated out-doors e.g. radiation and temperature. They can also be used to show how the response to a particular environmental factor depends on previous history. Different artificial climates can be made by changing conditions at various times during the growth period or at specific stages of growth. Information about the effects of weather can be obtained by moving plants between natural and controlled environments. For example, controlled deviations from the seasonal climatic trend can be made by moving plants from a population growing out-doors to growth rooms for short periods, and then returning them to complete their growth in the natural climate.

Environmental factors may affect yield via the size of the photosynthetic system, the rate of photosynthesis or the capacity of the storage organs to accumulate carbohydrate. Experiments in controlled environments can help to establish the relative importance of these processes in controlling yield when a particular environmental factor is altered.

5.8 WATSON, D. J. & FRENCH, S. A. W. (1971) Interference between rows and between plants within rows of a wheat crop, and its effects on growth and yield of differently-spaced rows. *J. appl. Ecol.* **8**. (In the press.)

By closing two adjacent spouts of the drill, a winter wheat crop was sown so that each drill width contained seven rows with nominal spacing of 7 in. (18 cm) (NS rows), two edge-rows each with 7 in. spacing on one side and 21 in. (53 cm) on the other (ER rows), and one row (WS) with 21 in. spacing on both sides. Samples for growth analyses were taken at fortnightly intervals from March to the final harvest in August from rows sown by each coulter of the drill.

ER rows continued to take up more nitrogen than NS rows throughout the growth period; they produced more shoots and ears per plant and per metre, and had more leaf area. The greater leaf area duration (D) of ER rows than of NS rows was the main cause of their larger dry weight per metre at ear emergence, and hence their larger straw yield, and accounted almost entirely for their larger grain yield. Net assimilation rate (E) before ear emergence was slightly greater for ER rows than NS rows, but the difference in grain : leaf ratio (G) between them was small and not significant.

WS rows absorbed more nitrogen per metre than ER rows, but had no more shoots or ears per metre because they had fewer plants. They had slightly less leaf area than ER rows before ear emergence, but more afterwards. Consequently, the larger straw yield of WS rows was wholly attributable to their larger E, but the larger grain yield was caused by greater D, and slightly greater G.

The spacing between NS rows, nominally 7 in., ranged from 4·8 to 8·5 in. (12·2–21·6 cm). NS rows with wider spacing had greater grain yield per metre because they had larger D after ear emergence, and G was independent of spacing, but increases in both D and E contributed to their greater dry weight at ear emergence. NS rows also differed in plant density; those with more plants per metre had greater yields of grain and straw, wholly because they had more leaf area.

Thus, edge rows grew larger and yielded more grain and straw than closely-spaced rows because they obtained more nitrogen, and probably other nutrients, from the soil and so produced more leaf area. Less mutual shading of leaves slightly increased photosynthesis by the

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edge rows before ear emergence, but very little afterwards and so had no effect on grain yields. These results imply that closely-spaced rows competed mainly for nutrients from the soil, and that competition for light was important only with wide spacing, when competition for nutrients was less severe.

Wider spacing produced stems that were larger in cross section. Stems from widely-spaced rows were also stronger than stems of the same area of cross section from narrowly-spaced rows. Presumably both these effects increase the resistance of edge rows to lodging.

5.9 WILLIAMS, E. D. (1970) Studies on the growth of seedlings of *Agropyron repens* (L.) Beauv. and *Agrostis gigantea* Roth. *Weed Res.* **10**, 321–330.

The growth of seedlings of *Agropyron repens* (L.) Beauv. and *Agrostis gigantea* Roth. in pots was studied in two experiments in 1968 and 1969. In Experiment 1 their growth was compared with that of wheat and in Experiment 2 they were grown in sandy loam (Woburn) and silt loam (Rothamsted) soil with four amounts of nitrogen.

Both species grew faster than wheat, mainly because they had a larger leaf area ratio. Tillering began earlier in wheat, but continued longer in the grasses, which eventually had many more shoots. Ears emerged in the order: wheat before *Agropyron* before *Agrostis*. Although *Agrostis* had much lighter seeds than *Agropyron*, it grew faster, but *Agropyron* initiated rhizomes sooner, usually when it had 1–2 tillers and four leaves. *Agrostis* did not initiate rhizomes until it had at least ten tillers and six leaves. In Experiment 2 the seedlings at first grew more in Woburn than in Rothamsted soil but later more in Rothamsted than in Woburn soil. There was no evidence of a species/soil interaction, but nitrogen had more effect on both species in Woburn than in Rothamsted soil. Neither soil type nor nitrogen affected the time when rhizomes were initiated.

5.10 WILLIAMS, E. D. (1970) Effects of decreasing the light intensity on the growth of *Agropyron repens* (L.) Beauv. in the field. *Weed Res.* **10**, 360–366.

Small plots of *Agropyron repens* (L.) Beauv. were shaded with 'Tygan' screening fabric which transmitted approximately 46% of daylight. In 1968, plots were either shaded or unshaded throughout the experiment (from mid-May until September) and in 1969, some plots were also shaded early (mid-May to mid-July) or late (mid-July to September). In both experiments continuous shading halved rhizome dry weight but had a much smaller effect on shoot dry weight. It also decreased rhizome dry matter content by 5%. With early shading there were fewer shoots and ears until mid-July but this difference disappeared by September, because plants shaded early produced more shoots and ears after mid-July than unshaded plants. Early shading slightly decreased the final percentage of shoots that developed ears. Early shading increased shoot height by mid-July and late shading increased it by the end of the experiment.

5.11 WILLIAMS, E. D. & (ATTWOOD, P. J.) (1971) Seed production of *Agropyron repens* (L.) Beauv. in arable crops in England and Wales in 1969. *Weed Res.* **11**, 22–30.

Spikes of *Agropyron repens* (L.) Beauv. were collected from field crops (mostly spring barley and winter wheat) in England and Wales near the time of crop harvest. Seeds per spike were counted and their germination tested in soil in the glasshouse.

About 95% of the samples contained viable seeds; about one-third of the samples had fewer than five viable seeds/spike, a third between six and 15 and a third more than 15. The average number of viable seeds/spike for all samples was 13. Spikes from spring barley (152 samples) had an average of 11 and a maximum of 51 viable seeds and those from winter wheat (42 samples), 20 and 48 respectively. Samples collected within 3 weeks after mid-July had fewer viable seeds/spike than those collected later. Samples containing morphologically-different spikes had more viable seeds/spike than apparently uniform samples, and spikes from dense field populations more seeds than those from sparse populations.

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Biochemistry Department

General Papers

6.1 Holden, M. (1970) Notes on the Agaric flora of Ghana. *Jl W. Afr. Sci. Ass.* (In the press.)

6.2 Pirie, N. W. (1970) Thirty years progress with leaf protein. *Cajanus* **3**, 279–287.

6.3 Pirie, N. W. (1970) Increasing the usefulness of internationally controlled research. In: *The ecology of food and nutrition.* (In the press.)

6.4 Pirie, N. W. (1970) Weeds are not all bad. (Fresh-water weeds as a resource.) *Ceres* **3**, (4), 31–34.

6.5 Pirie, N. W. (1970) Enzyme actions in Food Technology. *Lancet* Vol. I for 1970, 879.

Paper in Rothamsted Report, Part 2

6.6 Pierpoint, W. S. (1971) Formation and behaviour of o-quinones in some processes of agricultural importance. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 199–218.

A general account of the enzymic production of o-quinones from o-dihydroxyphenols, their metabolic roles in plants and arthropods, and some of the consequences of their formation in harvested, stored or decaying plant materials.

Research Papers

6.7 Arkcoll, D. B. & Festenstein, G. N. (1971) A preliminary study of the agronomic factors affecting the yield of extractable leaf protein. *J. Sci. Fd Agric.* **22**, 49–56.

The main factors influencing protein production by species selected for their ability to synthesise protein rapidly were; nitrogenous fertiliser, age at harvest, seed rate, climate, disease and growth regulators. These factors were examined to find how much they affect the extraction and yield of protein. Some of the best species were grown either through a season or in sequence with one or more other species, with optimum conditions and cut to give maximum protein yields. Annual yields as large as 2000 kg/ha were obtained in a good year with winter wheat followed by two crops of mustard or fodder radish. Some species that yield well did not extract well by old methods. Improvements in extraction methods allowed them to be used. The best was cocksfoot grass, which gave 1670 kg/ha in a very dry year and can be expected to give 2000 kg/ha regularly in wetter parts of the British Isles.

6.8 Byers, M. (1971) The amino acid composition and *in vitro* digestibility of some protein fractions from three species of leaves of various ages. *J. Sci. Fd Agric.* **22** (In the press.)

Extracts from leaves of barley (*Hordeum vulgare*), lupin (*Lupinus albus*) and chinese cabbage (*Brassica chinensis*) of different ages were fractionated by centrifuging and controlled heating. As the leaves age chloroplasts are increasingly disrupted during extraction and the chlorophyll-containing protein becomes increasingly difficult to sediment. The amount of protein unassociated with chlorophyll does not vary with leaf age, but does differ between species.

Analyses are given of selected chloroplastic fractions sedimented at 70 × **g** to 80 000 × **g**, and coagulated by heating to around 45°, and on the protein precipitated from the whole extracts and the various supernatant fluids. The amino acid composition of unfractionated protein is independent of species, except perhaps for methionine: leaf age has no affect on composition. The method of protein-precipitation may, however, influence the amount of lysine determined. Contrary to previous reports, chloroplastic and cytoplasmic (i.e. that which is precipitated from chloroplast-free extracts) protein do not have the same composition: both contain the same amounts of aspartic acid, proline, alanine, valine and methionine, and differ only slightly in their contents of threonine, serine, glutamic acid, iso-leucine, tyrosine, phenyl-

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alanine and arginine, but there is less leucine and substantially more histidine and lysine in the cytoplasmic than in the chloroplastic fraction. These differences in composition between the various fractions, and between species, show most clearly when the analyses are classified statistically.

The nutritional properties of the various preparations are discussed in relation to their amino acid composition and to their known *in vivo* and *in vitro* behaviour. Comparison with the FAO reference protein shows enough lysine, both total and nutritionally 'available', in unfractionated and cytoplasmic protein, though it may be marginal in some chloroplastic fractions. The first limiting essential amino acid in all leaf protein preparations is methionine, and there is an adequate amount 'available' in cytoplasmic but not in unfractionated or chloroplastic protein. Reasons are suggested for the unavailability of methionine, and possibly cyst(e)ine, in the latter preparations.

6.9 CURRIE, J. A. & FESTENSTEIN, G. N. (1971) Factors defining spontaneous heating and ignition of hay. *J. Sci. Fd Agric.* **22** (In the press.)

The ways in which heat balance, water balance and aeration interact in the self-heating of hay beyond 70°C were examined in the laboratory. A temperature-controlled environment is essential for the temperature of small hay samples to exceed 70°C; the rate air flows through the apparatus must be slower than that required for self-heating below 70°C, to restrict loss of latent heat caused by increased water vapour transfer; otherwise air at the same relative humidity as the hay must be used. Some water is essential for hay to self-heat beyond 70°C, but self-ignition occurs only when most of the water has been lost at or near 100°C. Theoretical considerations show that the latent heat transfer exceeds the thermal conductivity of hay above 20°C, increases by one order of magnitude by 65°C, two by 95°C and infinitely by 100°C.

6.10 FESTENSTEIN, G. N. (1971) Carbohydrates in hay on self-heating to ignition. *J. Sci. Fd Agric.* **22** (In the press.)

The self-heating of moistened hay beyond 70°C, the maximum temperature reached by thermophilic micro-organisms, was studied in a temperature-controlled apparatus. The pH decreased on heating from 6·2 to 3·8. Fructosan was rapidly degraded to fructose, which then also decreased. More hemicellulose than cellulose was broken down and the resulting products, monomers and polymers of pentose and glucose, increased correspondingly in aqueous extracts; hay self-heated to 165°C contained little free sugar and pentose polymers were the only remaining soluble carbohydrates. Hay incubated with water at 80°C showed changes similar to hay self-heated between 70° and 100°C.

6.11 HILL, J. M. (1970) The cytochrome-c catalysed oxidation of ascorbate in the presence of sodium dodecylsulphate and NNN′N′-tetramethyl-p-phenylene diamine. *Biochem. J.* **118**, 677–678.

Anionic- but not neutral- or cationic-detergents react with cytochrome-c. This modified cytochrome-c, unlike untreated cytochrome-c, catalyses the rapid aerobic oxidation of ascorbate in the presence of NNN′N′-tetra-methyl-p-phenylene diamine. Hydrogen peroxide is formed. In the presence of catalase, 1 g-atom of O_2 is absorbed for each molecule ascorbate oxidised. Cytochrome-c cannot be replaced by other haem-proteins or haematin. The Soret band of the modified cytochrome-c is at 396 nm and is intensified slightly under anaerobic conditions; no absorption peaks are found between 500 and 600 nm. Both ferri- and ferro-cytochrome-c react with sodium dodecyl sulphate to give identical end products. After chromatography of modified cytochrome-c on Sephadex G-25 columns, cytochrome-c, indistinguishable from ferricytochrome-c is recovered in the eluate.

6.12 HOLDEN, M. (1970) Chlorophyll bleaching systems in leaves. *Phytochemistry* **9**, 1771–1777.

Chlorophyll was bleached when leaves of various species were incubated in aqueous acetone solutions at pH 6 in the dark, but not when they were suspended in solutions of several surface-

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active compounds. Leaves that bleached in aqueous acetone were rich in lipoxidase but a few with large activity did not bleach appreciably. Although leaves with little lipoxidase activity did not bleach, pheophytin or pheophorbide was sometimes formed and decreased the absorption of pigment-containing extracts. Adding glycollate to chloroplast-containing aqueous extracts of wheat and barley leaves caused chlorophyll to bleach, but glycollate oxidation seems not to be involved in the bleaching in leaves in aqueous acetone.

6.13 JERVIS, L. & (HALLAWAY, H. M.) (1970) Isolation of ribosomes from cell-wall preparations of barley (*Hordeum vulgare*). *Biochem. J.* **117**, 505.

Ribosomes can be released from highly purified preparations of the cell walls of barley shoots by passing the suspension of cell walls through a French press. The sedimentation coefficients and base composition of the cell wall ribosomes are identical with those of cytoplasmic ribosomes.

Plant Pathology Department

GENERAL PAPERS

7.1 GIBBS, A. J. (& HARRISON, B. D.) (1970) Cucumber mosaic virus *C.M.I./A.A.B. Descriptions of plant viruses* No. 1.

7.2 GIBBS, A. J. & (PAUL, H. L.) (1970) Echtes Ackerbohnemosaik virus. *C.M.I./A.A.B. Descriptions of Plant Viruses* No. 20.

7.3 GIBBS, A. J. & (SMITH, H. G.) (1970) Broad bean stain virus. *C.M.I./A.A.B. Descriptions of Plant Viruses* No. 29.

7.4 KASSANIS, B. (1970) Satellite virus. *C.M.I./A.A.B. Descriptions of Plant Viruses* No. 15.

7.5 KASSANIS, B. (1970) Tobacco necrosis virus. *C.M.I./A.A.B. Descriptions of Plant Viruses* No. 14.

7.6 LACEY, J. (1969) Spores in the air of farm buildings. In: *Filtration in medical and health engineering*. (Filtration Society Symposium, London, April 1969), pp. 66–64.

7.7 LACEY, J. (1970) The case for chemicals. *Dairy Farmer* April, 62–65.

7.8 MACFARLANE, I. (1970) Germination of resting spores of *Plasmodiophora brassicae*. *Trans. Br. mycol. Soc.* **55**, 97–112.

7.9 MACFARLANE, I. (1970) *Lagena radicicola* and *Rhizophydium graminis*, two common and neglected fungi. *Trans. Br. mycol. Soc.* **66**, 113–116.

7.10 SALT, G. A. (1970) Conifer seedling pathology. *Rep. Forest Res. London, 1970*, 174–175.

7.11 SLOPE, D. B. (1970) Disease problems of intensive cereal growing. *Rep. Proc. Pertwee Cereal Growers Conf. 1970*, 22–33.

7.12 WATSON, M. A. (1969) Viruses, vectors and vegetation. *World Review of Pest Control* **8**, 4, 186–189.

7.13 WATSON, M. A. (1971) Transmission of plant viruses by aphids. In: *Plant virology: principles and techniques*. Van Nostrand Reinhold Company.

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Paper in Rothamsted Report, Part 2

7.14 Salt, G. A. (1971) Soil fumigation and root-rots of wheat. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 138–146.

This paper describes the direct, residual and cumulative effects of formalin soil treatment on take-all and other fungal diseases of spring and winter wheat grown with a range of N dressings at Rothamsted. The effects on take-all are closely correlated with those on yield (Widdowson & Penny, *Rothamsted Report for 1969*, Part 2, 113–134).

Research Papers

7.15 Bailey, L., Gibbs, A. J. & Woods, R. D. (1970) A simple way of purifying several insect viruses. *J. gen. Virol.* **6**, 175–177.

(For summary see No. 11.6.)

7.16 Bowden, J., Gregory, P. H. & Johnson, C. G. (1971) Possible wind transport of coffee leaf rust across the Atlantic Ocean. *Nature, Lond.* **229**, 500–501.

(For summary see No. 10.16).

7.17 Brown, M. E. & Hornby, D. (1971) Behavior of *Ophiobolus graminis* on slides buried in soil in the presence or absence of wheat seedlings. *Trans. Br. mycol. Soc.* **56**, 95–103

(For summary see No. 4.10.)

7.18 Carpenter, J. M. (1970) The stacked-disk structure of tobacco mosaic virus protein. *Virol.* **41**, 603–614.

The protein of TMV polymerises slowly in alkaline solution (pH 8–10·5) to form rod-shaped particles which have the stacked-disk structure. The polymerisation process has been followed by electron microscopy and analytical centrifugation; possible mechanisms are discussed.

The particles are resistant to changes in buffer concentration and pH, and are not in equilibrium with their precursors. They are degraded only at a pH above 12 or below 2 and are resistant to proteolytic enzymes. Electrophoresis indicates that the particles consist of more than one structural type.

7.19 (Cross, T.) & Lacey, J. (1968) Studies on the genus *Thermomonospora*. *The Actinomycetales*. Ed. H. Prauser. VEB Gustav Fischer Verlag, Jena, pp. 211–219.

More than 40 thermophilic, white, monosporic actinomycetes isolated from natural substrates were compared with type cultures and other isolates of species of *Thermomonospora*, *Actinobifida*, and *Thermoactinomyces*. An almost continuous range of morphological variation was found between two extremes represented by *Thermonospora viridis* and *Thermoactinomyces vulgaris*. Sporophores on the aerial mycelium showed varying degrees of dichotomous branching, and a number of cultures had spores on the vegetative mycelium on simple or dichotomously branched sporophores. The range of variation included types described as distinct species of *Thermonospora* and *Actinobifida*. The taxonomy of this group is discussed and suggestions made of ways in which it might be clarified.

7.20 Ebbels, D. L. (1970) Effect of fumigants on fungi in buried wheat straw. *Trans. Br. mycol. Soc.* **54**, 227–232.

Applying formalin to soil in the field significantly decreased the survival of *Cercosporella herpotrichoides* in surface litter. 'D-D' had no effect on the incidence of *Fusarium roseum* in such litter, but both formalin and dazomet soil treatments decreased it. 'D-D' and chloropicrin injected into soil columns at 150 mm depth were always more effective in killing fungi below the point of injection than above it. None of the fumigants tested eradicated *C. herpotrichoides*, *F. roseum*, or *Ophiobolus graminis* in straws near the soil surface.

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7.21 GOVIER, D. A. & KLECZKOWSKI, A. (1970) Inactivation by ultraviolet radiation at different wavelengths of the RNA isolated from potato virus X. *Photochem. Photobiol.* **12**, 345–353.

The action spectra and quantum yields for photoreactivable, non-photoreactivable and total damage caused by u.v. in the RNA isolated from potato virus X differ from those for similar types of damage in the whole virus. The differences result from the virus protein partly protecting the RNA from damage, and the degree of protection depends on the wavelength of u.v. and on the salt concentration of the irradiated solution. The action spectra for the different types of damage in the RNA all resemble the absorption spectrum of the RNA, but do not exactly parallel it. The photoreactivable sectors of the RNA and of the whole virus are greater at 290 nm than at 230 nm but, whereas that of the virus increases rectilinearly, that of the RNA has a pronounced minimum at about 250 nm. At wavelengths longer than 240 nm, the photoreactivable sector of the virus exceeds that of the RNA, because, at these wavelengths, the virus protein protects the RNA more against non-photoreactivable damage than against photoreactivable damage.

7.22 HIRST, J. M., HIDE, G. A., GRIFFITH, R. L. & STEDMAN, O. J. (1970) Improving the health of seed potatoes. *Jl R. agric. Soc.* **131**, 87–106.

Field inspections have succeeded in freeing potato seed stocks from most virus diseases, but surveys of tubers show that pathogenic fungi are common on all grades of seed from all areas, although the prevalence of individual ones differs between varieties, years and localities. The fungi that causes such diseases as skin spot, gangrene, stem canker and silver scurf only exceptionally decrease the yield of ware crops by more than a few per cent, but they also rot tubers and affect quality by causing blemishes or increasing the size range of tubers.

Some types of loss can be lessened by palliative treatments, but these do not eliminate the fungi. Uninfected tubers can be produced by rooting stem cuttings, and such tubers are being used to initiate new stocks. However, although the main source of infection is now from seed tubers, the fungi can survive in field soils between successive potato crops. Hence, the healthy stocks need protecting while being bulked to commercial amounts, and there is evidence that this will be possible by the recently developed systemic fungicides. There seems good prospect of improving the health of seed tubers, and thereby increasing the yield of ware crops. However, with some varieties, some of this increase may be in tubers smaller than ware size.

7.23 JONES, F. G. W., CARPENTER, J. M., PARROTT, D. M., STONE, A. R. & TRUDGILL, D. L. (1970) Potato cyst nematode: one species or two? *Nature, Lond.* **227**, 83–84.

(For summary see No. 8.22.)

7.24 KASSANIS, B. & PHILLIPS, M. P. (1970) Serological relationship of strains of tobacco necrosis virus and their ability to activate strains of satellite virus. *J. gen. Virol.* **9**, 119–126.

Antisera prepared in rabbits against strains of tobacco necrosis virus (TNV) or satellite virus (SV) were most specific in precipitation tube tests when animals were bled after single intravenous injections. In Ouchterlony tests, antisera remained equally specific after further injections, including one intramuscular injection. However, all antisera and both test methods agreed in placing the eight strains of TNV tested in two distinctive groups or serotypes. The three strains of SV tested differed as much antigenically from one another as did strains of the two serotypes of TNV, although SV_1 and SVc were more closely related to each other than to SV_2.

Some strains of TNV aid the multiplication of SV_1 and SV_2 but not of SVc; others aid SVc but not SV_1 or SV_2. The ability of different strains of TNV to aid the multiplication of the three strains of SV is correlated with their ability to infect tobacco and bean plants, but not their serological relationship.

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7.25 KASSANIS, B., VINCE, D. A. & WOODS, R. D. (1970) Light and electron microscopy of cells infected with tobacco necrosis and satellite viruses. *J. gen. Virol.* **7**, 143–151.

French-bean leaves inoculated with the stipple streak strain of tobacco necrosis virus alone or mixed with the satellite virus were examined microscopically. Light microscopy showed two types of inclusion in some living epidermal cells, one hyaline, the other granular and containing small crystals. Some cells also contained crystals different in form from those in the inclusions. Light microscopy of parenchymatous cells fixed and stained for electron microscopy showed only one type of inclusion, with smooth appearance. The crystals seen in the living cells were not found, but some cells from leaves infected with the mixture had areas containing both heavily stained amorphous material and bodies 1 to 2 μm across.

Electron microscopy of thin sections of the same fixed and stained material showed some cells to contain a structureless, electron-dense material, prominent cytoplasmic membranes and many vesicles, especially from leaves inoculated with the mixture. The electron-dense material often contained satellite virus in crystalline arrays and sometimes rhombic plates 1 to 2 μm long. Whenever satellite virus was identified, tobacco necrosis virus occurred near to it. Cells infected with tobacco necrosis virus alone had well-defined areas in which the virus was concentrated and apparently uncontaminated. These areas corresponded to the inclusions seen in the light microscope. The relative frequency with which particles of the two viruses were detected by electron microscopy of leaf sections differed from the relative concentration of the two estimated by serological assays on sap extracted from leaves inoculated with the mixture.

7.26 LAPWOOD, D. H. & (HERING, T. F.) (1970) Soil moisture and the infection of young potato tubers by *Streptomyces scabies* (common scab). *Potato Res.* **13**, 296–304.

Majestic potatoes planted in soil naturally infested with *Streptomyces scabies* were trickle irrigated to prevent infection of tubers except during consecutive 7 day periods during the first eight weeks when tubers were developing (28 May to 23 July).

During each interval without irrigation, lesions of scab affected an average of four internodes on the tubers but the later water was withheld, the closer to the apex of tubers was the infection at final lifting. The tubers with most area scabbed were those unwatered between 11 and 18 June, the third week from tuber initiation, when the first-formed internodes, which expand more than later-formed ones, became infected.

7.27 LAPWOOD, D. H., (WELLINGS, L. W. & ROSSER, W. R.) (1970) The control of common scab of potatoes by irrigation. *Ann. appl. Biol.* **66**, 397–405.

Irrigation applied early during tuberisation significantly decreased scab on tubers of Majestic, King Edward and Record, but had a small effect on scab-resistant Pentland Crown, which showed little scab even on the tubers from the driest regime. There was little benefit from keeping soils wetter than 0·6 in. (15 mm) soil moisture deficit (S.M.D.) for more than 3 weeks after tuber initiation, and an 0·8 in. (20 mm) S.M.D. treatment gave economic control. Irrigating only after the 'marble stage' increased yield but the tubers were scabbed. Irrigation did not alter the rate of eye (node) separation on tubers but made their volume increase faster.

7.28 SLOPE, D. B. & ETHERIDGE, J. (1971) Grain yield and incidence of take-all (*Ophiobolus graminis* Sacc.) in wheat grown in different crop sequences. *Ann. appl. Biol.* **67**. (In the press.)

The yield of wheat and the incidence of take-all were measured in crops grown in six different 4-year sequences, repeated in three successive years. The first crop of winter wheat grown after oats or beans yielded 13–23 cwt/acre (1632–2887 kg/ha) more grain than wheat after wheat or barley. Spring wheat after oats yielded 2–5 cwt/acre (250–625 kg/ha) more than spring wheat after wheat. The smaller yields of wheat after wheat or barley were caused mostly by greater prevalence of take-all. Regression analysis indicates that each 1 % increase in straws with take-all decreased yield of winter wheat by 0·6 %. Take-all was more prevalent in the second and third successive wheat crops after oats than in the fourth crop.

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7.29 SLOPE, D. B., ETHERIDGE, J. & (CALLWOOD, J. E.) (1970) The effect of flame cultivation on eyespot disease of winter wheat. *Pl. Path.* **19**, 167–168.

Flame cultivation of wheat stubble, before or after ploughing, did not decrease the incidence of eyespot in July in the following winter wheat crop.

7.30 WILLIAMS, T. D. & SALT, G. A. (1970) The effects of soil sterilants on the cyst-nematode (*Heterodera avenae* Woll.), take-all (*Ophiobolus graminis* Sacc.) and yields of spring wheat and barley. *Ann. appl. Biol.* **66**, 329–338.

(For summary see No. 8.29.)

Nematology Department

THESIS

8.1 SANTOS, M. S. N. DE A. (1970) Studies on the reproduction and sexual behaviour of some species of *Meloidogyne* Goeldi, 1887 (Nematoda: Heteroderidae). Ph.D. thesis, University of London.

FILM

8.2 DONCASTER, C. C., NUTMAN, P. S. & BELL, F. (1970) Nitrogen fixation in lucerne. London, British Film Institute.

GENERAL PAPERS

8.3 CORBETT, D. C. M. & WEBB, R. M. (1970) Preliminary nematode population studies in continuous wheat under two systems of cultivation. *Proc. IX international Nematology Symposium, Warsaw, 1967*, 369–370.

8.4 DONCASTER, C. C. (1971) Feeding in plant parasitic nematodes: mechanisms and behaviour. In: *Plant parasitic nematodes* Vol. 2, Ed. B. M. Zuckerman, *et al.* New York: Academic Press, pp. 137–157.

8.5 FRANKLIN, M. T. (1970) Morphological variability and the species concept. (Introduction to a discussion.) *Proc. IXth International Nematology Symposium, Warsaw, 1967*, 497–503.

8.6 FRANKLIN, M. T. (1971) Interrelationships of nematodes, weeds, herbicides and crops. *Proc. 10th British Weed Control Conference, 1970*, Vol. 3, 927–933.

8.7 FRANKLIN, M. T. (1971) Taxonomy of Heteroderidae. In: *Plant parasitic nematodes* Vol. 1, Ed. B. M. Zuckerman, *et al.* New York: Academic Press, pp. 139–161.

8.8 GREEN, C. D. (1970) Mating of cyst forming nematodes. *Proc. IXth International Nematology Symposium, Warsaw, 1967*, 189–191.

8.9 GREEN, C. D. (1971) Mating and host finding behaviour of plant nematodes. In: *Plant parasitic nematodes* Vol. 2, Ed. B. M. Zuckerman, *et al.* New York: Academic Press, pp. 247–266.

8.10 JONES, F. G. W. (1970) The control of potato cyst-nematode. John Curtis 'Woodstock' Lecture. *Jl R. Soc. Arts* **118**, 179–199.

8.11 JONES, F. G. W. (1970) How to tackle the potato cyst-eelworm. *Fmr Stk Breed.*, April, 39–43, May, 47, 49, 52.

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8.12 SHEPHERD, A. M. (1970) The influence of root exudates on the activity of some plant parasitic nematodes. In: *Root diseases and soil borne pathogens. (Part Proceedings of the 1st International Congress of Plant Pathology, London (1968).)* Ed. T. A. Toussoun, *et al.* Berkeley and Los Angeles: University of California Press, pp. 134–137.

8.13 SHEPHERD, A. M. & CLARKE, A. J. (1971) Molting and hatching stimuli. In: *Plant parasitic nematodes* Vol. 2, Ed. B. M. Zuckerman, *et al.* New York: Academic Press, pp. 267–287.

PAPER IN ROTHAMSTED REPORT, PART 2

8.14 WHITEHEAD, A. G., DUNNING, R. A. & COOKE, D. A. (1971) Docking disorder and root ectoparasitic nematodes of sugar beet. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 219–236.

Ectoparasitic nematodes, especially species of *Trichodorus* (stubby root nematodes) and *Longidorus* (needle nematodes), feed on and damage the root tips of sugar beet; Docking disorder is the poor growth of sugar beet resulting from this primary damage. Yield loss does not depend only on the number of nematodes in the soil, but also on other interacting factors, especially soil structure and rainfall, which affect the numbers and activity of the nematodes, the nutrients available to the seedlings and the vigour of root growth. Modern cultural practices, especially the use of herbicides and drilling to a stand, probably increase the prevalence and severity of Docking disorder. Approximately 20 000 acres of sugar beet suffered from Docking disorder in 1969, at an estimated yield loss exceeding 50 000 tons of roots. Damage can be alleviated by replacing the nitrogen lost by leaching, and it can be prevented by nematicides. Fumigating all the top soil with 'D-D' or 'Telone' kills nearly all the nematodes and greatly increases the yield of sugar beet and other crops in the rotation, but is expensive. Small amounts of fumigant or systemic nematicides applied to the sugar-beet rows at or before sowing kill most of the nematodes in the rows, or prevent them from feeding on the roots, allowing the seedlings to grow vigorously, and can greatly increase yield.

RESEARCH PAPERS

8.15 CLARKE, A. J. (1970) The composition of the cyst wall of the beet cyst-nematode *Heterodera schachtii*. *Biochem J.* **118**, 315–318.

Cyst walls of the beet cyst-nematode (*Heterodera schachtii* Schmidt) were obtained by sieving a suspension of crushed cysts; about 15 mg of dried cyst walls was obtained from 1000 cysts. The cyst walls contained 68% protein calculated from nitrogen content. Glutamic acid, glycine, proline and hydroxyproline made up about 54% by weight of the amino acids obtained on acid hydrolysis. Minor constituents of the cyst wall were hexosamine (3·3%), lipid (6%), carbohydrate (2%) and phenols (2%). The hexosamine was identified as galactosamine. The cyst walls contained inorganic material (ash 17%), most of which was extractable with EDTA, but not with water. Major inorganic components were calcium and phosphorus (1·7% and 1·5% respectively, by weight). Carbon dioxide (about 1% by weight) was liberated from the cyst walls on acidification. The cyst walls of *H. schachtii* and the potato cyst-nematode (*Heterodera rostochiensis*) contained different amounts of the same amino acids. They also differed in their inorganic content and in the nature of the hexosamine present.

8.16 CORBETT, D. C. M. (1970) Root lesion nematodes (*Pratylenchus* spp.) in Britain and their identification. *Pl. Path.* **19**, 59–64.

A key is given, with drawings and descriptions to identify the following species of *Pratylenchus* recorded in Britain: *P. convallariae*, *P. crenatus*, *P. fallax*, *P. flakkensis*, *P. minyus*, *P. penetrans*, *P. pinguicaudatus*, *P. pratensis*, *P. thornei* and *P. vulnus*.

8.17 EVANS, K. (1970) Longevity of males and fertilisation of females of *Heterodera rostochiensis*. *Nematologica* **16**, 369–374.

After emerging from roots, *H. rostochiensis* males remained active for 9 or 10 days whether females were present or not. Females attracted males up to 15 cm away, but when isolated

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remained fertilisable for at least 40 days beyond the time when they would normally be fertilised. When allowed to mate on plants, some females were fertilised as soon as 24 days after the roots were invaded by the larvae. Very young females seemed able to store enough sperm to fertilise all their eggs. Most females were mated soon after they ruptured the root cortex and within a few days of males beginning to emerge. All females were mated within 50 days of roots being invaded.

8.18 EVANS, K. (1970) The effects of gamma radiation on *Heterodera rostochiensis*. *Nematologica* **16**, 284–294.

All stages of *H. rostochiensis* were exposed to doses of up to 64 kilorads of gamma radiation. Exposing cysts to potato root-diffusate made them more sensitive to radiation than air-dried cysts. Irradiation of larvae had no effect on their activity, but irradiation of either cysts or larvae impaired development of the F_1 generation. Larger doses were required to affect the fertility of adults, and females were more susceptible than males, probably because the primary oocytes continue dividing after mating, whereas all the sperm is formed by the time the males leave the roots. Larvae from irradiated cysts competed poorly with those from unirradiated cysts when potato plants were inoculated with mixtures of the two.

8.19 FISHER, J. M. (1970) Growth and development of *Aphelenchus avenae* Bastian, 1865. *Aust. J. biol. Sci.* **23**, 411–419.

Increases in length and breadth of larvae of *Aphelenchus avenae* followed a roughly sigmoid pattern with plateaux representing the motionless phases of moulting. During these phases length decreased slightly, resulting in withdrawal of the head and tail from the old cuticle, and increased again as movement was resumed after the moult.

It was not always necessary for a larval stage to feed and increase in size before it could moult. The crucial time in a stage was when moulting could occur without further feeding. The period before this depended on the previous feeding of the larvae; the period spent in a stage afterwards was constant. Growth of the gonad was related to this control stage and occurred without feeding, though faster when the larvae had fed. Size of adults depended partly on the amount of feeding between the time when moulting could first occur and the onset of the motionless phase.

8.20 GOWEN, S. R. (1970) Observations on the fecundity and longevity of *Tylenchus emarginatus* on Sitka spruce seedlings at different temperatures. *Nematologica* **16**, 267–272.

Tylenchus emarginatus fed and reproduced on Sitka spruce seedlings growing in water agar without obviously damaging them. Temperature changes between 10°–25°C affected the rate eggs were laid and longevity of the nematodes but not the total viable eggs produced. The generation time at 25°C was between 5 and 6 days. Nematodes did not reproduce at 30°C or colder than 10°C and eggs failed to hatch after incubation at these temperatures. *T. emarginatus* can rarely reproduce in the field between November and April and probably overwinters as juvenile and adult stages.

8.21 GREEN, C. D., GREET, D. N. & JONES, F. G. W. (1970) The influence of multiple mating on the reproduction and genetics of *Heterodera rostochiensis* and *H. schachtii*. *Nematologica* **16**, 309–326.

Females of *Heterodera rostochiensis* Woll. embedded in agar or peat were inseminated more readily than in sand. Females removed from their host plants with small pieces of root attached lived longer and produced more eggs than those taken from roots. Males of *H. rostochiensis* attracted each other slightly but were much more strongly attracted to females. When females were in groups, males at a distance responded to the groups as a whole, rather than to individuals, but when near to the group they tended to be 'captured' by a single female near the edge of the group. Males of *H. rostochiensis* and *H. schachtii* Sch. seemed able to inseminate up to ten females. Fecundity depended more on the age of the females when taken from the roots than the number of males that inseminated them.

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Kort's results from single-cyst cultures seems to fit the hypothesis that the ability of some larvae of *H. rostochiensis* to become females in the roots of eelworm resistant potatoes depends on a recessive gene occurring infrequently. Multiple mating would cause more diversity of genes in the offspring of one female. Grouping of females on roots enhances their attractivenes and, as males leave females they have recently mated, less attractive females have the opportunity of being fertilised.

8.22 JONES, F. G. W., CARPENTER, J. M., PARROTT, D. M., STONE, A. R. & TRUDGILL, D. L. (1970) Potato cyst nematode: one species or two? *Nature, Lond.* **227**, 83–84.

Differences in measurements, in the colour of the females, in host ranges and inability to interbreed suggest that the so-called pathotypes B and E of *Heterodera rostochiensis* are a distinct species from pathotype A. As pathotype A, the golden nematode, occurs in the type locality and is therefore strictly *H. rostochiensis*, both species need to be redescribed and the new species needs a specific name.

8.23 PARROTT, D. M. & TRUDGILL, D. L. (1970) Variations in the resistance to *Heterodera rostochiensis* of potatoes derived from *Solanum tuberosum* ssp. *andigena* and *S. multidissectum*. *Ann. appl. Biol.* **65**, 385–391.

The proportion of larvae from ten populations of *Heterodera rostochiensis* Woll. that become female was determined on five potato clones containing genes for resistance derived from *S. tuberosum* ssp. *andigena*, on three with genes from *S. multidissectum* and on four with genes for resistance from both sources. Variations in the resistance of the clones bred from *andigena*, especially to two of the populations, suggest the presence of more than one gene for resistance.

8.24 TRUDGILL, D. L., PARROTT, D. M. & STONE, A. R. (1970) Morphometrics of males and larvae of ten *Heterodera rostochiensis* populations and the influence of resistant hosts. *Nematologica* **16**, 410–416.

Pathotype B and E larvae of *H. rostochiensis* differed from those of pathotype A in having longer stylets and greater distances between the median bulb and the excretory pore. A population from Bolivia resembled pathotype A, but reproduced on ex *andigena* potato hybrids.

8.25 WHITEHEAD, A. G., FRASER, J. E. & GREET, D. N. (1970) The effect of 'D-D', chloropicrin and previous crops on numbers of migratory root-parasitic nematodes and on the growth of sugar beet and barley. *Ann. appl. Biol.* **65**, 351–359.

Thirty-three gal 'D-D' or chloropicrin/acre (371 l/ha) injected during winter into well-drained, sandy soils controlled *Longidorus attenuatus*, *Trichodorus* spp. and other migratory root-parasitic nematodes and greatly increased yields of sugar beet for at least 3 years; 2 years of bare fallow was less effective than soil fumigation. *Trichodorus* spp. multiplied more on sugar beet than on barley, whereas *L. attenuatus* multiplied more on barley and clover than on sugar beet.

8.26 WHITEHEAD, A. G. & HOOPER, D. J. (1970) Needle nematodes (*Longidorus* spp.) and stubby-root nematodes (*Trichodorus* spp.) harmful to sugar beet and other field crops in England. *Ann. appl. Biol.* **65**, 339–350.

Longidorus attenuatus produces galls at the tips of roots of field crops, including sugar beet, growing in alkaline, sandy soils in eastern England. *L. elongatus* produces similar, but often larger, galls on the roots of sugar beet and other crops in sandy soils in the W. Midlands and in Fen peats. *Trichodorus* spp. cause 'stubby root' of sugar beet and can feed on many field crops. Seven species of *Trichodorus* were found in sandy soils in eastern England. *L. attenuatus*, *L. elongatus* and *Trichodorus* spp. aggregate around roots and stunt sugar beet and other crop plants. *L. attenuatus* is commoner below plough depth than in the topsoil, whereas *T. cylindricus*, *T. pachydermus* and *T. anemones* are more abundant in the topsoil. These nematodes cause some forms of 'Docking disorder'.

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8.27 WHITEHEAD, A. G., TITE, D. J. & FRASER, J. E. (1970) The effect of small doses of nematicides on migratory root-parasitic nematodes and on the growth of sugar beet and barley in sandy soils. *Ann. appl. Biol.* **65**, 361–375.

Smaller amounts of 'D-D' (6–12 gal/acre) (68–135 l/ha) or ethylene dibromide (9 gal/acre) (100 l/ha) than are customarily used to disinfest field soils killed many root-parasitic nematodes (*Trichodorus*, *Pratylenchus*, *Tylenchorhynchus* and *Longidorus attenuatus*) when injected 6–8 in. (15–20 cm) deep during early autumn in rows 10 in. (25 cm) apart in well-drained sandy soils. They also increased the yield of sugar beet grown in fields infested with *Trichodorus* or *Longidorus attenuatus*, without affecting sugar percentages or juice purity of the roots, and in some places increased the yield of barley grown after the beet. 'D-D' was much less effective when injected 8–12 in. deep during late autumn or winter. Increasing nitrogen dressings to the seedbed from 1·5 to 3 cwt/acre (188 to 376 kg/ha) increased sugar-beet yield in one field, decreased it in another and decreased juice purity in both. In two other experiments extra nitrogen did not affect sugar-beet yield.

Even smaller amounts of nematicides 'placed' in the rows, before or after sowing sugar beet in them, killed many of the nematodes and also increased sugar yield. Phytotoxic nematicides can be placed in the rows during autumn, winter or spring but placement is simpler during spring, when the treated rows are indicated by the position of the marks of the tractor wheels left when the nematicide was applied. When applied during autumn or winter, the rows need to be indicated by drilling wheat or grass.

8.28 WILLIAMS, T. D. (1970) Barley segregates resistant and susceptible to the cereal cyst-nematode (*Heterodera avenae* Woll.). *Ann. appl. Biol.* **66**, 339–346.

In the first year of this experiment both nematode-resistant and susceptible segregates of spring barley were equally invaded by *Heterodera avaenae* larvae, but few females developed in the roots of the resistant plants and eggs in the soil were fewer after the resistant crop. In the second year, a commercial, nematode-susceptible variety yielded significantly more grain following the resistant segregate. The resistant segregate, derived from *Hordeum pallidum* var. 191, suppresses the development of *Heterodera avenae* pathotypes 1 and 2 [British nomenclature] and should be useful in areas where these pathotypes predominate.

8.29 WILLIAMS, T. D. & SALT, G. A. (1970) The effects of soil sterilants on the cereal cyst-nematode (*Heterodera avenae* Woll.), take-all (*Ophiobolus graminis* Sacc.) and yields of spring wheat and barley. *Ann. appl. Biol.* **66**, 329–338.

In a 3-year field experiment on sandy loam at Woburn, methyl bromide, chloropicrin, 'D-D' mixture, dazomet, formalin and mercury salts were applied in the first year only, or in the first and second year, before drilling spring wheat. In the third year, their residual effects on spring barley were measured. All sterilants except mercury decreased cereal cyst-nematode (*Heterodera avenae*) numbers and take-all (*Ophiobolus graminis*) incidence, and increased crop yields in the year they were applied. Dazomet gave the best control of *H. avenae* in the first year and controlled *O. graminis* best in both years of application. In the third year, *O. graminis* increased in all plots previously treated (except after two successful 'D-D' treatments), but *H. avenae* increased only after formalin. Two formalin applications more than trebled the *H. avenae* egg count by the end of the third year and depressed the yield of barley. Two successive applications of chloropicrin gave the best nematode control.

Other fungus diseases, *Fusarium* foot rot, *Pythium* root rot, eye-spot (*Cercosporella herpotrichoides* Fron.) and sharp eye spot (*Rhizoctonia solani* Kühn), were uncommon and sterilants had no detectable effects on them. The largest aggregate straw yield (3-year total) was obtained from two applications of dazomet, but the best yields after treatment in the first year only were given by 'D-D' and methyl bromide.

8.30 YEATES, G. W. (1970) The diversity of soil nematode faunas. *Pedobiologia* **10**, 104–107.

Besides information on feeding, biomass and respiration, faunal lists are necessary to indicate the relative importance of the species of soil nematodes. It is suggested that species be listed in

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order of decreasing abundance and that the total number of species, the fewest species required to comprise 75% of the fauna and the number of species comprising at least 2% of the fauna be noted. Five faunas from the Orkney Islands are presented in this way. Thirty-six nematode faunas from natural or near natural terrestrial habitats are analysed and contain an average of 24 species of which six are required to comprise 75% and nine species comprise at least 2% of the fauna.

Insecticides and Fungicides Department

General Papers

9.1 Burt, P. E. (1970) Biophysical aspects of nervous activity in relation to studies on the mode of action of insecticides. *Pesticide Science*. **1**, 88–92.

9.2 Callow, R. K. (1970) Pheromones. *M&B Laboratory Bulletin*, **IX**, iii, 43–45.

9.3 Graham-Bryce, I. J. & Briggs, G. G. (1970) Pollution of soils. *R.I.C. Reviews* **3**, 87–104.

9.4 Graham-Bryce, I. J. & Etheridge, P. (1970) Influence of soil factors on uptake of systemic insecticides by plants. *Proc. VII int. Congr. Plant Protection, Paris, September 1970*, 136–138.

9.5 McIntosh, A. H. (1970) Testing chemicals for control of potato common scab. *Proc. VII int. Congr. Plant Protection, Paris, September 1970*, 389–391.

9.6 Needham, P. H. & Stevenson, J. H. (1970) Bees in agriculture. Bee poisoning in 1969. *Bee World* **51**, 62.

9.7 Stevenson, J. H. (1970) Field assessment of pesticide poisoning on honeybees (*Apis mellifera*). *Proc. VII int. Congr. Plant Protection, Paris, September 1970*, 780–781.

Research Papers

9.8 Arnold, A. J. (1970) A measured volume dispenser for watering plants. *J. agric. Engng Res.* **15**, 323–324.

An apparatus is described that dispenses preset volumes of water or nutrients to plants in pots.

9.9 Banks, C. J. & Needham, P. H. (1970) Comparison of the biology of *Myzus persicae* Sulz. resistant and susceptible to dimethoate. *Ann. appl. Biol.* **66**, 465–468.

Apterous *Myzus persicae* resistant to dimethoate reproduce for the same length of time as susceptible aphids, but the resistant ones reproduce significantly faster during the first 10 days of adult life (especially during the first 5 days). Thereafter, they reproduce more slowly, and eventually the susceptible aphids produce approximately the same number of larvae. Resistant aphids die significantly younger. Resistant aphids as larvae develop faster than susceptible ones and are significantly heavier when they first become adult. The resistant aphids do not excrete faster during the first few days but, as they produce more larvae during the first 10 days of adult life and have developed faster, they probably feed faster during development and early adult life or obtain more nutritious food.

Resistant aphids were at least as effective as susceptible ones in transmitting sugar-beet mosaic and pea mosaic viruses, and plants showed symptoms sooner when resistant aphids were the vectors.

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9.10 BURT, P. E. & GOODCHILD, R. E. (1971) The site of action of pyrethrin I in the nervous system of the cockroach *Periplaneta americana* L. *Ent. exp. appl.* **14**. (In the press.)

Neurophysiological techniques were used to assess the effect of pyrethrin I on conduction of action potentials in giant fibres and on the amount of spontaneous activity in sixth abdominal ganglia of adult male cockroaches (*Periplaneta americana* L.). In tests on isolated nerve preparations, concentrations of pyrethrin I less than $10^{-7}M$ had little effect on giant fibres whereas concentrations as small as $10^{-10}M$ affected the amount of activity in the ganglia. Giant fibres from cockroaches previously treated topically with LD95s of pyrethrin I were hardly affected 1–4 hours after poisoning, when the insects were severely affected, but the amount of activity in sixth abdominal ganglia at this time was greatly increased. Some intra-ganglionic neurons are therefore much more susceptible than giant fibre axons to poisoning by pyrethroids, which suggests that the fatal lesions caused by pyrethroids probably occur within the ganglia rather than in peripheral nerve.

The effects of pyrethrin I on giant fibres resembled those described by Narahashi (1962) for allethrin, but pyrethrin I was about 30 times more active.

9.11 (CASIDA, J. E.), ELLIOTT, M., (KIMMEL, E. C.) & JANES, N. F. (1971) Oxidative metabolism of pyrethrins in mammals. *Nature, Lond.* **230**, 326.

The botanical insecticidal esters, pyrethrins I and II, are rapidly degraded by oxidation of the *trans*-methyl group of the isobutenyl side in pyrethrin I, hydrolysis of the methoxycarbonyl group in pyrethrin II, and oxidation of the pentadienyl group in both pyrethrins, as determined by oral administration of ^{14}C- and ^{3}H-labelled compounds to rats and characterization of excreted metabolites by nmr and mass spectroscopy. The related synthetic insecticide, allethrin, is metabolised similarly. Rapid metabolism may explain the small toxicity of pyrethrins and allethrin to mammals.

9.12 (CROMBIE, L., ELLIS, J. A., PATTENDEN, G.), ELLIOTT, M., JANES, N. F. & JEFFS, K. A. (1971) Oxidative dimerisations of natural rethrolones and related compounds using manganese dioxide. *J. Chem. Soc.* (*C*). 9–13.

Oxidation of allethrolone and naturally derived pyrethrolone with manganese dioxide under controlled conditions gives the corresponding diones. Under more vigorous conditions oxidations lead to novel tetraone dimers. Cinerolone and jasmololone are similarly oxidised by manganese dioxide to the corresponding diones but seem not to give rise to tetraone dimeric products.

9.13 ELLIOTT, M., FORD, M. G. & JANES, N. F. (1970) Insecticidal activity of the pyrethrins and related compounds. III.—Penetration of pyrethroid insecticides into mustard beetles (*Phaedon cochleariae*). *Pesticide Science* **1**, 220–223.

Substituted benzyl chrysanthemates are lost from the surface of *Phaedon cochleariae* Fab. at rates correlated with their toxicities to this insect, less toxic compounds in general being lost faster. The forms of the penetration curves are explained by a model system in which movement into the insect is eventually balanced by detoxification, and relative detoxification rates for the members of the series of compounds are deduced from this model. Such values assist interpretation of relations between structure and activity by indicating to what extent susceptibility to detoxification limits the potency of the less toxic compounds.

9.14 ELLIOTT, M., JANES, N. F. & JEFFS, K. A. (1970) The pyrethrins and related compounds. X. The methylbenzyl chrysanthemates. *Pesticide Science* **1**, 49–52.

New or improved routes are used to prepare all the 19 methylbenzyl chrysanthemates, including 2,4,6-trimethylbenzyl (+) and (−)-*trans*-chrysanthemates, 2,3,4,6-tetramethyl- and 2,3,4,5,6,-pentamethylbenzyl chrysanthemates, and the chrysanthemates of the new alcohols, 2,3,5- and 3,4,5-trimethylbenzyl alcohols.

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9.15 ELLIOTT, M., JANES, N. F. & PAYNE, M. C. (1971) The pyrethrins and related compounds. XI. Synthesis of insecticidal esters of 4-hydroxycyclopent-2-enones (norrethrins). *J. Chem. Soc.* (*C*). (In the press.)

2-Benzylcyclopent-2-enones, obtained by rearrangement of the corresponding benzylidenecyclopentanones, are brominated by N-bromosiccinimide at the 4-position; the products upon treatment with silver chrysanthemate give new analogues of the natural pyrethrins.

9.16 ELLIOTT, M., JANES, N. F. & PEARSON, B. C. (1971) The pyrethrins and related compounds. XII. 5-Substituted 3-furoates and 3-thenoates, intermediates for synthesis of insecticidal esters. *J. Chem. Soc.* (*C*). (In the press.)

Chloromethylation of 3-furoates, followed by Friedel Crafts reaction, gives 5-aralkyl-3-furoates. Such compounds and the corresponding 3-thenoates are more conveniently synthesised by condensing the ethylene acetals of 5-substituted levulinic esters with ethyl formate. The resulting 2-formyl-4-oxoester derivatives are cyclised directly by aqueous acids to give furans and by phosphorus pentasulphide to the corresponding thiophens.

9.17 ELLIOTT, M., (KIMMEL, E. C. & CASIDA, J. E.) (1969) ^{3}H-Pyrethrin I and -pyrethrin II: preparation and use in metabolism studies. *Pyrethrum Post* **10**, No. 2, 1–6.

The insecticides pyrethrins I and II labelled with ^{3}H in the alcohol and of high specific activity are prepared for investigations of their degradation, metabolism, and mode of action. In rethrolones such as (±)-allethrolone NMR spectroscopy shows that in deuterium oxide containing K_2CO_3 six protons (*HO*, CH_2CO and CH_3) are rapidly replaced by deuterium without attack at the C4 asymmetric centre. ^{3}H-(+)-Pyrethrolone is obtained under comparable conditions in tritiated water and esterified with natural chrysanthemic and pyrethric acids to give optically pure ^{3}H-pyrethrin I and ^{3}H-pyrethrin II, respectively. In studies with mixtures of ^{3}H-alcohol- and ^{14}C-acid-labelled pyrethrin I incubated with house fly and rat liver mixed-function oxidase systems, the major metabolites have the same ^{3}H : ^{14}C ratio as the substrate used, indicating that hydrolysis of the ester and exchange of ^{3}H are not significant reactions.

9.18 GRAHAM-BRYCE, I. J. (1970) Polarography of demeton, disulfoton and phorate. *Pesticide Science* **1**, 73–74.

The polarographic response obtained when demeton-S, disulfoton and phorate, in 2% tetraethyl ammonium hydroxide, were investigated using a cathode ray oscilloscope polarograph depended considerably on the interval between making up solutions and measurement. Direct evidence confirming previous suggestions that this type of behaviour is from hydrolysis of the original insecticides to polarographically active SH-containing compounds was obtained by measuring the disappearance of the original insecticides from the solution by gas–liquid chromatography, and by investigating the behaviour of the hydrolysis product for demeton-S and disulfoton synthesised by an independent route. Measurements of electrocapillary curves, and other lines of evidence, indicate that the electrode process involves adsorption/desorption at the mercury drop. The results emphasise that conditions must be carefully standardised when polarography is used to estimate these insecticides.

9.19 GREGORY, G. E. (1970) Silver staining of insect central nervous systems by the Bodian protargol method. *Acta Zool., Stockh.* **51**, 169–178.

Factors that control staining of paraffin sections of central nervous system ganglia in *Periplaneta americana* (L.) and *Schistocerca gregaria* Forsk. by the Power double-impregnation version of the Bodian protargol silver technique were analysed. Fixation of the tissue, copper content and pH of the protargol solution, duration of impregnation, and developer composition all influence the intensity, colour and selectivity for nerve fibres of the stain by affecting the two fractions of silver, reduced and unreduced, deposited in the section during impregnation. The factors interact so that similar staining can result from different combinations of conditions. Suitable conditions are suggested for almost total staining of nerve fibres or highly selective staining for tracing individual fibres.

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9.20 GRIFFITHS, D. C., LORD, K. A. & SCOTT, G. C. (1970) Some experiments with different formulations of organophosphorus insecticides as seed dressings to control Wheat Bulb-fly (*Leptohylemyia coarctata*). *Pesticide Science* **1**, 3–4.

Experiments on the control of Wheat Bulb fly larvae by seed dressings compared four organophosphorus compounds in standard siliceous earth formulations with special formulations of the same compounds in polyvinyl acetate, polypropylene or wax. The special formulations allowed more insecticide to be placed on the seeds without affecting germination. Counting shoots damaged by Wheat Bulb fly larvae showed that: siliceous earth formulations of diazinon gave good control which was not improved by special formulations; control with siliceous earth formulations of dimethoate was poor and was improved only little by the special formulations; control with siliceous earth formulations of parathion and dichlofenthion was moderate and was improved by special formulations, especially polyvinyl acetate and polypropylene. The results suggest that special formulations are of most value with compounds that are moderately effective but where the amount of insecticide in standard seed dressings cannot be increased without damaging the plants.

9.21 GRIFFITHS, D. C., SCOTT, G. C., (MASKELL, F. E., MATHIAS, P. L. & ROBERTS, P. F.) (1970) The effects of known amounts of γ-BHC and organophosphorus seed dressings on growth of wheat seedlings and on attack by larvae of wheat bulb fly (*Leptohylemyia coarctata* (Fall.)). *Pl. Path.* **19**, 111–118.

Six trials were done during three years (1966–69) in eastern England to study how known amounts of insecticidal seed dressings affect the growth of winter wheat and the severity of attack by Wheat Bulb fly larvae. In the first two years γ-BHC dry dressing was applied to seeds previously treated with a liquid organomercury fungicide, but in the third year seeds were dressed with powders containing fungicide mixed with the insecticides γ-BHC, chlorfenvinphos or ethion. Analysis using gas–liquid chromatography showed that the ethion + fungicide dressing stuck to the seeds much better than the chlorfenvinphos + fungicide dressing or either formulation of γ-BHC. Some ethion γ-BHC and chlorfenvinphos later fell off the seeds, the exact amount depending on the method of drilling. Small amounts of insecticide, less than about 10 μg/seed of γ-BHC or less than about 15 μg/seed of the organophosphorus compounds, were ineffective against Wheat Bulb fly. Increasing amounts of all three insecticides progressively decreased the percentage of damaged shoots and the percentage of plants with live larvae, but more of the organophosphorus insecticides, especially of ethion, was usually needed to give the same protection as γ-BHC. No seed treatment damaged seedlings in trials on peaty loams or sandy clay loams, but seeds dressed with the standard amount of liquid organomercury fungicide and several different amounts of γ-BHC dry dressing germinated poorly in the sandy loam soils.

9.22 GRIFFITHS, D. C. & WALKER, N. (1970) Microbiological degradation of parathion. *Meded. Faculteit Landbouw-Wetenschaffen Gent.* **35**, 805–810.

(For summary see No. 4.13.)

9.23 MCINTOSH, A. H. (1970) Tests of dibutyltin compounds as potato blight fungicides. *Ann. appl. Biol.* **66**, 115–118.

Dibutyltin dicarboxylates were about one-tenth as effective as fentin acetate in controlling potato haulm blight (*Phytophthora infestans*) in laboratory tests on detached leaflets, but were less phytotoxic. Tributyltin acetate was no more effective than dibutyltin diacetate; dioctyltin dichloride was ineffective.

9.24 MCINTOSH, A. H. (1970) A glasshouse method for testing chemicals for control of potato common scab. *Potato Res.* **13**, 241–247.

Plants of scab-susceptible varieties (Majestic or Maris Piper) were grown in pots in the glasshouse in field soil infested with *S. scabies*, with or without added chemicals; the stolons were confined to the top 4 cm of soil by a buried layer of 'Terylene' net and the plants, when well rooted, were watered from saucers only. Tubers became heavily scabbed in untreated soil.

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Results from comparative glasshouse tests and field trials of seven chemicals agreed well on both scab-control and yield. The glasshouse method was quick (8 weeks or possibly less) and could be used throughout most of the year.

9.25 NEEDHAM, P. H. & SAWICKI, R. M. (1971) Diagnosis of resistance to organophosphorus insecticides in *Myzus persicae* (Sulz.). *Nature, Lond.* **230**, 125.

The cross-resistance and ali-esterase activity of several strains of *Myzus persicae*, resistant to organophosphorus insecticides, is described. The ali-esterase activity is correlated with the degree of resistance and differs from that of houseflies.

9.26 PHILLIPS, F. T. (1971) Mathematical models as aids in understanding weathering processes of pesticide deposits. *Proc. VII int. Congr. Plant Protection, Paris, September 1970*, 750–751.

Loss rates of organochlorine insecticides were measured when aldrin and dieldrin crystals were allowed to volatilise under different conditions and when DDT wettable powder formulations were 'rainwashed' from different surfaces. Four models of equations of exponential type were applied to each experimental result, and the parameters of the equations were chosen by computer to give the best fit to the experimental plotted points. In the volatilisation studies, the best-fitting model depended on the type of surface (glass or leaf) and on the porosity of the surface when under different humidity conditions. In the 'rainwashing' studies, double exponential models gave the best fits on all surfaces, showing that two simultaneous processes were occurring, probably the impaction effect of water droplets on the more friable parts of the deposits and the longer term effect of particle-wetting before suspension or solution.

9.26 PHILLIPS, F. T. & GILLHAM, E. M. (1971) Persistence to rainwashing of DDT wettable powders. *Pesticide Science*. (In the press.)

A mixture of amine stearates ('LOVO', a proprietary product of Fisons Ltd) greatly diminished the amounts of DDT removed by 'rainwashing' deposits of wettable powders on glass or cotton leaf surfaces. The age and density of the deposit affected retention less. Rates of loss by 'rainwashing' from both types of surface could be described in general terms by double exponential equations.

The initial rate DDT penetrated into cotton leaves, but not the amount that penetrated after several weeks in the laboratory at 20°C, was influenced by the presence of 'LOVO' in the spray suspension. The proportional amounts, and the total amounts, of DDT that penetrated from these unweathered deposits depended on the deposit density.

9.28 SAWICKI, R. M. (1970) Interaction between the factor delaying penetration of insecticides and the desethylation mechanism of resistance in organophosphorus-resistant houseflies. *Pesticide Science* **1**, 84–87.

The desethylation (gene *a*) and penetration delaying (*pen*) factors of resistance to organophosphorus insecticides isolated by genetical methods from the diazinon-selected SKA strain of houseflies (*Musca domestica* L.) were inbred into a strain whose resistance was compared with that of flies with single factors of resistance and the SKA strain. *Pen* alone decreases kill marginally, and gene *a* alone raises LD_{50} to 1·4–48 times that of susceptible flies, depending on the insecticide. The two factors together increase resistance greatly to many organophosphorus insecticides (up to 5–10 times or more to diazinon, malathion-ethyl and chlorthion-ethyl than of flies with gene *a* only) indicating that the two factors interact. Interaction is greater against the thionates than the corresponding phosphates, probably because *pen* delays entry of thionates more than of the corresponding phosphates. The role in resistance of each factor when hetero- and homozygous, and the reasons for interaction, are discussed.

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9.29 SAWICKI, R. M. (1971) Interaction between factors of resistance in a strain of houseflies polygenic for resistance to organophosphorus insecticides. *Proc. VII int. Congr. Plant Protection, Paris, September 1970*, 808–811.

Houseflies of the SKA strain are very resistant to organophosphorus insecticides because of their three mechanisms of resistance, viz. delayed penetration, desethylation and microsomal detoxication. Singly these mechanisms confer little or no resistance. When desethylation and delayed penetration are together, they interact to give strong resistance—much greater than the sum or product of each factor singly. Desethylation and microsomal detoxication when together do not interact but act independently and total resistance equals the product of individual resistances. This shows that in insects with polygenic resistance neither the likelihood nor the degree of resistance against insecticides can be predicted.

9.30 SAWICKI, R. M. & LORD, K. A. (1970) Some properties of a mechanism delaying penetration of insecticides into houseflies. *Pesticide Science*, **1**, 213–217.

The penetration of insecticides into houseflies, with and without the factor that delays penetration, was studied by measuring the amounts of the insecticides on the surface of the flies at intervals after treatment. The factor slowed the entry of all the insecticides tested, but its effect depended on the dose, and had little or no effect when the dose applied was big (20 μg/fly). Penetration in all strains, susceptible and resistant, increased but not proportionally to the size of the dose. The rate insecticide was lost from the surface slowed with time and increasing age of the insects. It was faster in males than females, and was always faster in flies without the penetration factor. The differences in penetration between the flies with and without the factor was less with n-dodecane as solvent than with acetone.

With all strains, rate of loss from the surface was slowest with dieldrin. Diazinon, parathion and chlorthion-ethyl were lost at about the same rate; diazoxon penetrated fastest.

Entomology Department

BOOK

10.1 EDWARDS, C. A. (1970) *Persistent pesticides in the environment*. Chemical Rubber Company Monoscience Series, Vol. 1, No. 1. Critical Reviews in Environmental Science, pp. 7–67.

GENERAL PAPERS

10.2 BARDNER, R. (1971) Interactions between soil-borne pests and other soil fauna elements. *Entomophaga*. (In the press.)

10.3 BARDNER, R. & FLETCHER, K. E. (1970) Prediction of losses caused by Wheat Bulb fly (*Leptohylemyia coarctata* Fall.). *Proc. VII int. Congr. Plant Protection, Paris, 1970*, 657–658.

10.4 (BURTON, J. F.) & FRENCH, R. A. (1969) Monarch butterflies coinciding with American passerines in Britain and Ireland in 1968. *British Birds* **62**, 493–494.

10.5 EDWARDS, C. A. (1970) Problems of insecticidal residues in agricultural soils. *PANS* **16**, 271–276.

10.6 EDWARDS, C. A. (1971) Actions and fate of insecticides in the soil. In: *Organic chemicals in the soil environment*. New York: M. Dekker. (In the press.)

10.7 EDWARDS, C. A. (1971) *Soil organisms*. In: *Encyclopedia Britannica*. (In the press.)

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10.8 EDWARDS, C. A., (REICHLE, D. E. & CROSSLEY, D. A.) (1970) The role of soil invertebrates in turnover of organic matter and nutrients. In: *Analysis of temperate forest ecosystems*. Berlin, Heidelberg, New York: Springer-Verlag, Ch. 12, pp. 147–172.

10.9 FLETCHER, K. E. (1970) The extraction from soil of small arthropods by the dry-funnel method. In: *Crop loss assessment methods. FAO Manual on the evaluation and prevention of losses by pests, diseases and weeds*. Rome: FAO.

10.10 FRENCH, R. A. (1967) Recent developments in the study of immigrant Lepidoptera in Great Britain. *Nature in Wales* **10**, No. 2, 69–73.

10.11 JUDENKO, E. (1971) The assessment of economic losses in yield of annual crops caused by pests, and the problem of the economic threshold. *Entomophaga*. (In the press.)

10.12 STEPHENSON, J. W. (1971) Slugs in agricultural and horticulture. *Chemicals & Farming*. (In the press.)

PAPER IN ROTHAMSTED REPORT, PART 2

10.13 TAYLOR, L. R. & FRENCH, R. A. (1971) Rothamsted Insect Survey. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 237–253.

Totals are given of 32 aphid species, or species groups, caught during periods of four weeks in 13 suction traps in Great Britain and Holland from 23 April to November 1970; also totals of 31 species of Macrolepidoptera from light traps at 47 sites in Great Britain during 1968 and at 62 sites during 1969.

RESEARCH PAPERS

10.14 (BARDNER, H.), EDWARDS, C. A., (ARNOLD, M. K. & ROGERSON, J. P.) (1971) The effects of swede midge (*Contarinia nasturtii*) on yield of swedes. *Entomologia exp. appl.* (In the press.)

Symptoms of attack by swede midge in S.E. and N.E. England were observed and classified as either primary or secondary. Primary symptoms, 'swollen petiole' and 'crumple leaf', were more frequent and reliable indicators of attack than the secondary symptoms, 'many neck' and 'cabbage top'.

There was an interaction between sowing date and ability to tolerate attack, and early-sown plants suffered less loss of yield than those sown late. Only in seasons unfavourable to swedes would this pest affect yields seriously.

10.15 BARDNER, R. & LOFTY, J. R. (1971) The distribution of eggs, larvae and plants within crops attacked by Wheat Bulb fly. *J. appl. Ecol.* (In the press.)

Fields at Rothamsted were sampled for several years to assess populations of Wheat Bulb fly eggs and larvae, and populations of wheat plants and shoots. The results fitted to the regression equation: Log $(S^2)_{10} = \log_{10} a + b \log_{10} m$, where S^2 is the variance, a is a sampling factor, b the 'index of aggregation' and m the mean. Randomly-distributed populations have $b = 1$, aggregated populations have $b > 1$, and populations with a tendency towards regular distributions have $b < 1$. Most of the variates had b slightly greater than one, i.e. the populations were only slightly aggregated and a square root transformation is appropriate for analysis of results from infested fields.

10.16 BOWDEN, J., GREGORY, P. H. & JOHNSON, C. G. (1971) Possible wind transport of coffee leaf rust across the Atlantic Ocean. *Nature, Lond.* **229**, 500–501.

Coffee Leaf Rust, *Hemileia vastatrix* Berk. & Br. was first detected in the New World, in Brazil, in 1970. It was thought to have been introduced mechanically because the measured falling speed of the uredospores was too great to permit long distance aerial transport and because relatively few had been trapped above infected coffee trees.

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However the following facts admit the alternative hypothesis of long-distance transport from Africa. *H. vastatrix* was detected in Angola in 1966; trade winds blow offshore of Angola directly to the affected areas in Brazil; new measurements of the falling speed of uredospores which show that former estimates were too great, also show that uredospores could remain airborne for the 5 to 7 days needed to cross the Atlantic Ocean to set up the scattered foci of infection that have been observed.

10.17 (Crossley, D. A., Reichle, D. E.) & Edwards, C. A. (1971) Intake and turnover of radioactive cesium by earthworms (Lumbricidae). *Pedobiologia* **11**, 71–76.

Earthworms of the species *Lumbricus terrestris* and *Octolasium* sp. were cultured in soil labelled with radioactive cesium (0·075 μCi/g). Other worms were cultured in unlabelled soil with cesium-labelled *Liriodendron tulipifera* litter (1 μCi/g) on the surface. At intervals the radioactivity in the earthworms was measured and corrected for radioactive decay. After maximum activity was reached (0·002 μCi/worm) earthworms were cultured with non-radioactive soil and litter, and their radioactivity counted frequently to measure the rate isotope was excreted. Earthworms fed on labelled litter gave a two-component excretion curve, and those fed on labelled soil without litter, a one-component curve. An equation and constants calculated for the curves resembled those obtained for arthropod species. Little cesium was assimilated and it was excreted rapidly. The slight assimilation allowed the amounts of soil consumed by worms to be calculated as 4·1 mg/hour/worm, which is equivalent to 1·2% of fresh body weight/hour.

10.18 Dean, G. J. & (Luuring, B. B.) (1970) Distribution of aphids in cereal crops. *Ann. appl. Biol.* **66**, 485–496.

Cereal crops were examined weekly for aphids during 1969. Plants in 20 samples of row 0·3 m long were examined in a sheltered perimeter of a crop and along a transect 36·6 m into the crop. Aphids were usually first found within 1 to 4 weeks of the first alatae caught in a suction trap operating 12·2 m above ground. When first found, from 10 to 27% of the 0·3 m lengths sampled contained aphids.

R. padi, first found late in May, were scarce (<0·53/0·3 m) throughout June and July. *Sitobion* spp. and *M. dirhodum*, which appeared in mid-June, were more numerous than *R. padi*; most occurred during the second half of July, and populations decreased just before harvest in early August. *S. avenae* was more abundant (max. 19·3/sample) than either *S. fragariae* (0·91) or *M. dirhodum* (2·51).

More aphids occurred in oats (max. 52/0·3 m) during July than in wheat (45), and barley had fewest (6·8). *S. avenae* was more abundant than *M. dirhodum* in sheltered areas of barley and wheat, and in exposed areas of the same crop *M. dirhodum* was commonest. Along sheltered perimeters, the ratio of *S. avenae* to *M. dirhodum* was largest in barley (11 : 1), intermediate in oats (6 : 1) and smallest in wheat (3·7 : 1). *Sitobion* spp. were most numerous on the ears, when most *M. dirhodum* were on the leaves.

Regression analyses of log S^2 on log m suggested that *S. avenae* was more evenly distributed within (36·6 m) the field ($b = 1{\cdot}056 \pm 0{\cdot}109$) than along the sheltered perimeter ($b = 1{\cdot}432 \pm 0{\cdot}132$), though it seemed similarly distributed along perimeters of barley, oats and wheat. The distributions of *M. dirhodum* and *Sitobion* spp. along sheltered perimeters of all crops were apparently similar.

10.19 Dean, G. J. & Wilding, N. (1971) *Entomophthora* infecting the cereal aphids, *Metapolophium dirhodum* Walk. and *Sitobion avenae* F. *J. Insect Path.* (In the press.)

Entomophthora aphidis, *E. planchoniana* and *E. thaxteriana* killed many *Metalophium dirhodum* and *Sitobion avenae* in barley during 1970. *E. planchoniana* first infected *M. dirhodum* late in June, after rain ended a long dry period, but few aphids were infected until after 7 July when heavy rain killed 65–80% of aphids. *E. planchoniana* was the most frequent of the three species until 27 July when *E. aphidis* and *E. thaxteriana* each became more abundant. *S. avenae* was more often infected by *E. thaxteriana* than the other species of *Entomophthora*. During the second half of July, 40–76% of adult *M. dirhodum* and 34–80% of *S. avenae* were infected. The three

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fungus species were equally common in *M. dirhodum* in sheltered fields but *E. thaxteriana* was less common in an exposed field. In a sheltered field *E. thaxteriana* was less frequent than the other species along the perimeter, and *E. planchoniana* was most common and *E. aphidis* least common about 37 m into the crop.

10.20 DIBLEY, G. C. & LEWIS, T. (1970) A bivane direction indicator and a sensitive vertical anemometer for measuring components of wind in sheltered places. *Ann. appl. Biol.* **66**, 469–475.

Two instruments are described: (1) a bivane direction indicator; (2) a vertical anemometer with the ancillary electronic recording equipment, for examining wind structure near windbreaks. Both instruments were designed to operate in slow winds.

10.21 EDWARDS, C. A. (1971) Effects of herbicides on soil fauna. *Proc. 10th Brit. Weed Control Conference, 1970*, **3**, 1052–1062.

Herbicides may affect populations of soil invertebrates either directly, or indirectly when the chemical affects the vegetation on which many of these animals feed. Direct effects of only DNOC, MCPA, 2,4-D, 2,4,5-T, TCA, dalapon, monuron, linuron, tri-allate, simazine, atrazine and paraquat have yet been studied and the only one that affected numbers of invertebrates were DNOC, TCA, monuron, simazine and 'Shell WL 19805'. The direct effects were never severe and with TCA and monuron occured only with very large doses. Three recent experiments with simazine, 'Shell WL 19805' and paraquat are described. Simazine and 'Shell WL 19805' slightly decreased numbers of enchytraeid worms, predatory mites and isotomid Collembola and 'Shell WL 19805' increased numbers and weight of earthworms. Paraquat had little effect on invertebrate populations. The only herbicides likely to influence numbers of soil invertebrates directly seem to be DNOC and the triazines. Their effects would not adversely affect soil fertility.

10.22 EDWARDS, C. A. & LOFTY, J. R. (1971) Influence of temperature on numbers of invertebrates in soil, especially those which affect primary production. *Symposium on Soil Zoology, Dijon, 1970.* (In the press.)

Two plots, 3 m square on old pasture, were surrounded with galvanised iron sheeting buried 45 cm deep and rising 30 cm above the soil surface. Eight 800 watt infra-red heaters fixed along the top of the sides and corners of the sheeting kept the top 2·5 cm of soil 5°–8°C above that in a similar unheated plot. Animals in different taxonomic groups reacted differently to the raised temperature from January onwards. The heated plot contained fewer larvae of Coleoptera and Diptera but many more Hemiptera and Thysanoptera.

The predatory mites were little changed until May by heat but then rapidly became fewer. Oribatid mites were much more numerous in the heated plot during the whole experiment. Collembola were not affected at first but they became more numerous in May and June then decreased in numbers; those species living near the surface were affected most by the warmth. Enchytraeid worms were soon eliminated from heated plots.

The warmth had little effect on total numbers or biomass of soil animals during spring but increased it from April to July and then decreased it. These changes were partly from the heat drying the soil.

10.23 FRENCH, R. A. (1971) Migration Records, 1966 and 1967. *Entomologist.* (In the press.)

10.24 (GOULD, G. E.) & EDWARDS, C. A. (1968) Damage to field corn by symphylans. *Proc. Indiana Acad. Sci. 1967*, **77**, 214–221.

Symphylans were studied in eight corn fields infested in five counties in Indiana during 1967 and 1968: Clinton, Shelby, Ohio, Harrison and Randolph. The species was *Scutigerella immaculata* Newport, except in Clinton County, where it was *S. nodicerous* Michelbacher. Only areas of 1 to 15 acres were attacked but damage within these areas was extensive. The roots of young

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corn were attacked soon after plants emerged and the plants died or were severely stunted within a week. Surviving plants remained stunted throughout the season and few produced even small ears. Many plants had 50 to 100 symphylans feeding on their fine roots. The infestations were usually on sloping land with uncompacted soil ruch in humus. In two fields, rows compacted by the tractor pulling the 6-row planter produced fewer injured plants than the other rows. In 1967 symphylans were not found in soil taken to a depth of 9 in. on 2 May, or at planting time on 27 May, but by 6 June there were up to 100 symphylans/plant and many plants were dying. This increase probably reflected movement from deeper soil rather than hatching of eggs. Plots treated with a fumigant or with any of six insecticides had only slightly fewer damaged plants than untreated plots.

10.25 HENDERSON, I. F. (1970) The fumigant effect of metaldehyde on slugs. *Ann. appl. Biol.* **65**, 507–510.

The fumigant effect of metaldehyde on slugs is confirmed almost certainly to be caused by impure metaldehyde breaking down to the volatile parent monomer, acetaldehyde. Acetaldehyde was slightly more toxic to *Agriolimax reticulatus* than to *Arion hortensis*.

10.26 JOHNSON, C. G. & BOWDEN, J. (1971) Problems related to the transference of insects between the Amazon and Congo areas, especially at the present time. *Proc. 4th int. Symp. of Ass. Trop. Biol., Accra, 1971.* (In the press.)

Some long distance migrations of insects across the sea and overland in relation to large scale weather systems are described briefly. Distances across the Atlantic Ocean between Africa and S. America, mainly within latitudes 15° N and 15° S, are considered in relation to possible length of flight of migrant insects. Many records of insects observed over the Atlantic between 15° N and S are mapped and discussed.

The flow of winds over the Atlantic Ocean in the tropics is considered. It is concluded that there is almost no possibility of transport of insects by flight from America to Africa within these latitudes. All the winds flow from Africa to S. America and the Caribbean. It is unlikely that a trans-Atlantic crossing could be made from Africa to America in the Doldrums. A trans-Atlantic crossing in the tropics therefore seems possible only from Africa to America and only in the region of the trade winds. There is no positive evidence of such a crossing being made.

The distribution of major insect pests in tropical Africa and tropical S. America is considered. The paradoxical situation was revealed that the insects common to both sides belong particularly to those species possessing wingless and parthenogenetic forms. It is concluded therefore that modern systems of insect migration by flight are adapted primarily for overland transport. It is the insects that are not adapted for such transport, but that are specifically adapted for staying with the habitat, that are most likely to cross the Atlantic Ocean (and in both directions) for they are carried across the sea with the habitat itself, such as with the transport of plant material, ballast, etc., or by aircraft or ships.

The consequences of these systems to the reciprocal infestation of the Congo and Amazon regions by pests from one or the other region are discussed.

10.27 JOHNSON, C. G., (BURGE, G. A.) & GIBBS, D. G. (1970) Field trials on anti-capsid insecticides on farmer's cocoa in Ghana, 1956–60. I. Comparing the effects of treatment by assessing subsequent damage. *Ghana J. agric. Sci.* **3**, 155–178.

Results from four series of field trials, done between 1956 and 1960 are described with a view to examining field procedures, and methods of analysing data, for assessing anti-capsid insecticides.

Assessing effects of insecticides by the amount of damage occurring after spraying and the canopy generation are considered. Two ways of assessing the amount of new damage and three ways of assessing its trend, are described and compared with each other. Two assessments at fortnightly intervals of new damage to foliage adequately assessed the amount of damage, and the difference between the amount of new damage at 4 and 12 weeks after spraying adequately assessed trend. Canopy assessment every six months also gave a good indication of the effects

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of spraying and could probably replace assessments of trend of new damage by fortnightly assessments.

The variability in the incidence of new damage on different crops after spraying was analysed and the number of replicates needed to detect differences between effects of different treatments considered, both when data were untransformed and transformed to logs. The value of pre-treatment assessment of damage and subsequent grading and blocking of crops is also discussed in relation to inter-plot variability.

The inclusion of untreated control plots in analyses of variance overestimated true errors in the comparison of treated plots and hampered the detection of differences between them. Controls were therefore unnecessary for detecting differences in the incidence of new damage; they are, however, essential for the comparison of canopy and regeneration, because some plots can improve even without spraying.

10.28 JOHNSON, C. G. & (BURGE, G. A.) (1971) Field trials of anti-capsid insecticides on farmer's cocoa in Ghana, 1956–60. II. Effects of different insecticides compared by counting capsids after spraying; and the method compared with that of counting the percentage of newly damaged trees. *Ghana J. Agric. Sci.* **4**. (In the press.)

All mobile stages of both species were counted to hand height on every tree in each plot and the numbers used to assess the effects of spraying.

The average number of capsids/100 trees (C/100T) assessed twice, four and six weeks after the second spraying, sufficiently indicated the initial effect of a 'treatment'. The average of five or six fortnightly counts did not improve the assessment enough to justify the extra work.

Counting newly damaged trees gave a slightly more reliable assessment than counting capsids. However, both methods gave similar results for assessing initial effects of insecticides.

Variability of capsids between experimental plots is of an order similar to that for newly damaged trees. With capsid counts, as with newly damaged trees, differences in effects of treatment could be reliably detected only when very large.

10.29 JONES, M. G. (1970) Infestation of wheat plants by the larvae of *Leptohylemyia coarctata* (Fall.) in an insectary. *Pl. Path.* **19**, 128–134.

When Wheat Bulb fly eggs were placed in a row between two rows of wheat plants 18 cm apart in seed boxes in an outdoor insectary, more of the newly hatched larvae invaded plants as the distance to the nearer row diminished; whereas only 61% succeeded when both rows were 9 cm away, 80% did so when the nearer row was 2 cm away and 87% when the eggs were placed between the plants in one row.

Some eggs hatched as late as mid-April.

Only about a quarter of the undamaged larvae dissected from shoots and placed in the soil near unattacked plants survived.

From 67 to 89% of the eggs failed to become adults. The proportion that failed increased as competition for host plants increased.

10.30 JONES, M. G. (1970) Observations on feeding and egg development of Wheat Bulb fly, *Leptohylemyia coarctata* (Fall.). *Bull. ent. Res.* **60**, 199–207.

The crops and guts of adults of *Leptohylemyia coarctata* (Fall.) from different parts of England and Scotland contained spores of *Septomyxa affinis*. This fungus is widespread on dead wheat leaves and grass in wheat fields and is an important food for the flies, especially in south and east England during July and August. Of all flies dissected in 1967, 1968 and 1969, 57%, 39% and 45%, respectively, contained *Septomyxa* spores; many contained spores of other fungi, pollen grains, bacteria and yeasts. All solid food was ingested in water or honeydew. Males were at their maximum weight when they emerged, whereas females almost doubled in weight with the ripening of the first batch of eggs. Different individuals had different numbers of ovarioles, so the number of eggs ripe and ready to lay at the same time also differed between individuals. The mean numbers, 25·6 ± 0·8 in 1968 and 28·6 ± 0·4 in 1969 were fewer than the

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usually accepted 32. During August, before all the eggs had been laid, many flies were killed by *Entomophthora muscae* and *Strongwellsea castrans*.

10.31 LEWIS, T. & DIBLEY, G. C. (1970) Air movement near windbreaks and a hypothesis of the mechanism of the accumulation of airborne insects. *Ann. appl. Biol.* **66**, 477–484.

Measuring different components of wind to leeward of artificial windbreaks showed that horizontal motion was the most important in affecting accumulations of airborne insects. Small air borne insects probably accumulate in sheltered places when they are diffused or convected into the recirculating air behind barriers. The concentrations probable theoretically were compared with concentrations measured in the field.

10.32 SHAW, M. J. P. (1970) Effects of population density on alienicolae of *Aphis fabae* Scop. I: The effect of crowding on the production of alatae in the laboratory. *Ann. appl. Biol.* **65**, 191–196.

A technique for rearing aphids in dense populations is described. Apterae were reared in dense ('C') and sparse ('U') populations and the proportions of alatae among their progenies were compared. Proportions of alatae were larger among progenies of 'C' apterae and the proportions also increased as the density of the population in which the progenies were reared increased. Progenies of alatae never became alatae.

10.33 SHAW, M. J. P. (1970) Effects of population density on alienicolae of *Aphis fabae* Scop. II: The effects of crowding on the expression of migratory urge among alatae in the laboratory. *Ann. appl. Biol.* **65**, 197–203.

Apterae reared at different population densities produced alatae among their progeny, but not all these alatae behaved in the same way. Some flew before depositing nymphs (here called migrants), others flew after parturition (flyers) and some never flew (non-flyers). The proportion of alatae, among the progeny from both uncrowded ('U') and crowded ('C') parents, that flew before depositing nymphs increased as the population density in which they were reared increased. Both crowded and uncrowded apterous parents produced similar numbers of larvae but, on average, 'C' apterae produced 17% more migrants. The proportions of migrants among alate progenies were closely correlated with the proportions of alatae among progenies.

10.34 SHAW, M. J. P. (1970) Effects of population density on alienicolae of *Aphis fabae* Scop. III: The effect of isolation on the development of form and behaviour of alatae in a laboratory clone. *Ann. appl. Biol.* **65**, 205–212.

A wide range of morphological differences, from apterae to alatae, and of differences in the behaviour of alatae were produced by isolating alatiform nymphs of *Aphis fabae* on successive days after their birth. Alatiform nymphs isolated soon after birth developed into the extreme apterous form, whereas when kept in a crowd until shortly before their final ecdysis a large proportion became alatae that flew before depositing young (migrants). Alatiform nymphs isolated on successive days after birth developed either into alatae that flew after depositing nymphs (flyers) or did not fly (non-flyers). Aphids thus show a continuous polymorphism, comparable to that of locusts, and possibly related to concentrations of juvenile hormone present in the aphid during larval development.

10.35 TAYLOR, W. E. & BARDNER, R. (1970) Energy relationships between larvae of *Phaedon cochleariae* (F.) (Coleoptera; Chrysomelidae) or *Plutella maculipennis* (Curt.) (Lepidoptera; Plutellidae) and radish or turnip plants. *Entomologia exp. appl.* **13**, 403–406.

Calorific values per gram of freeze-dried leaves, roots, pupae and larvae faeces were used to convert dry weights of plants and insects into measurements of energy content. The decreased yield, or loss of energy, of plants from injuries to leaves caused by a single insect during its larval life differed considerably between each of the four possible combinations of insect and

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plant, ranging from 0 to 22 times the energy content of the leaf tissue eaten by the larva and 0 to 76 times the energy content of the pupa.

The quantity of food needed by the larvae of the beetle *Phaedon cochleariae* (F.), and of the moth *Plutella maculipennis* (Curt.), and the effects of the insects on the growth and yield of radish and turnip was described by Taylor & Bardner (*Rothamsted Report for 1968*, Part 1, Abstracts 10.31, 10.32). Dry weights of plant and animal tissue were used to measure the amount of food eaten, and the growth of insects and plants. This method is not entirely satisfactory for measuring the conversion of plant into animal tissue, as plants usually have more carbohydrate and less fat than insect tissue and therefore have less energy/gram of dry weight. When the calorific values of plant and insect tissue are also measured, some of the energy relationships between plants and insects can be calculated.

10.36 THOMPSON, A. R., EDWARDS, C. A., (EDWARDS, M. J. & BEYNON, K. I.) (1970) The movement of dieldrin through soils. II. In sloping troughs and soil columns. *Pesticide Science* **1**, 174–178.

A glass-lined trough was divided into six compartments by vertical transverse partitions and filled with soil to a height of 5 cm above the top of each partition. The base of the box and the surface of the soil sloped towards one end with a gradient of 1 in 3·7. The movement of dieldrin applied (22 kg a.i./ha) to the soil surface in the uppermost compartment into the leachate and down the slope was followed for 17 weeks, during which time 19·5 cm of rain fell. Less than 0·02% of the dieldrin appeared in the leachate and 99% of this was collected during the first nine weeks, mainly from the uppermost compartment. Very little dieldrin moved down the slope and it was not detected in the leachate from compartments other than the treated one, later than nine weeks after treatment.

In other experiments, three cylinders were filled with sandy loam, heavy clay loam or peat, and transferred from the field as intact cores. Three other cylinders were filled with soils of the same types but broken up. Approximately 2% of the dieldrin leached through one column but usually much less than 0·1% did. The most dieldrin was leached down columns of heavy clay loam and least down sandy loam. Ten times as much dieldrin leached down the columns of intact soil as down those with broken soil.

The results indicate that too little dieldrin is probably leached from treated soil for this to be a major way in which water systems become contaminated.

Bee Department

BOOK

11.1 FREE, J. B. (1970) Insect pollination of crops. London: Academic Press.

GENERAL PAPERS

11.2 BUTLER, C. G. (1970) Chemical communication in insects: behavioral and ecologic aspects. In: *Advances in chemoreception*. Vol. 1. Ed. J. W. Johnston. New York: Appleton-Century-Crofts.

11.3 FREE, J. B. (1970) Pollinating insects. In: *Beneficial insects and mites*. Min. of Agric. Fish. & Fd bull. **20**. London: H.M.S.O.

PAPERS IN ROTHAMSTED REPORT, PART 2

11.4 BAILEY, L. (1971) Virus diseases of the honeybee. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 171–183.

A review of work done at Rothamsted and of relevant work elsewhere.

https://doi.org/10.23637/ERADOC-1-125 *pp 44*

11.5 FREE, J. B. (1971) Management of honeybee colonies for crop pollination. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 184–198.

A review of work done at Rothamsted.

RESEARCH PAPERS

11.6 BAILEY, L., (GIBBS, A. J. & WOODS, R. D.) (1970) A simple way of purifying several insect viruses. *J. gen. Virol.* **6**, 175–177.

Dense nucleus virus (DNV) of *Galleria mellonella* was most simply purified by the method suitable for acute bee paralysis and sacbrood virus. Preparations of DNV made this way from larvae injected when about half-grown were free from the much slow sedimenting material obtained by other workers and from injected fully-grown larvae.

11.7 BUTLER, C. G., (FLETCHER, D. J. C.) & WATLER, D. (1970) Hive entrance finding by honeybee (*Apis mellifera*) foragers. *Anim. Behav.* **18**, 78–91.

The behaviour of homecoming bees when the position of the entrance to their hive was changed while they were out was studied. When the change caused much confusion, the bees soon re-orientated in flight to the new entrance, but when confusion was slight, many bees alighted at the old entrance site and ran to the new one. Initially, such a trail of running bees formed only when 100 or more bees approached the hive together. On alighting, bees ran in all directions until one happened to find the new entrance and started dispersing Nassanoff gland scent, so attracting the other bees. Within a few minutes a trail of bees, many dispersing scent, formed between the old and new positions of the entrance. Any visual landmark between the entrances greatly aided trail formation and alone enabled the bees to learn the way. Once a bee had learned the way, some continued to alight near the old entrance site and run from there to the new one, even when they approached the hive individually. However, many bees that ran between the entrances for some time eventually learned to fly round to the new entrance after visiting the old entrance, and most of these finally reorientated to the new entrance completely.

11.8 FREE, J. B. (1970) The flower constancy of bumblebees. *J. Anim. Ecol.* **39**, 395–402.

Nearly all bees collected pollen on some trips and nectar only on others; most of the exceptions were observed for a few trips only. Only a few of the local species of flowers were visited much for pollen. Bees foraging on these showed a greater constancy per trip than bees foraging on other species. The most popular pollen often occurred as a minor constituent of loads that were predominantly of other pollens. *Bombus lucorum* foragers visited fewer flower species and had purer loads than *B. agrorum* foragers. Pollen-gatherers from two *B. lucorum* colonies made different use of the flowers available, suggesting that the colony somehow influences an individual bee's choice of forage. *B. lucorum* foragers showed day-to-day constancy and about 70% collected their original pollen type on the tenth day after the first observation. Inconstant bees sometimes collected the same mixtures of pollen on successive trips.

11.9 FREE, J. B. (1970) The behaviour of wasps (*Vespula germanica* L. and *V. vulgaris* L.) when foraging. *Insectes Sociaux* **17**, 11–19.

While foraging on dead adult and pupal honeybees, individual wasps showed little conformity in the order in which they dismembered their prey; they attempted to take as large loads as possible and preferred abdomens and thoraces to heads. Although wasps always removed some of the appendages from thoraces, especially the hind- and middle-legs, the presence of these appendages did not encourage foraging or facilitate recognition of the prey. Pupae were preferred to newly emerged bees, and newly emerged bees to old bees, probably because of the difference in hardness of the cuticle. Whereas wasps learned to divide adult bees' bodies at the neck and waist, they showed considerable adaptability when dismembering pupae and when confronted with unusual situations. Although individuals tended to become conditioned to collecting one type of prey, some changed from collecting adults to collecting pupae. Wasps could easily be enticed away from meat by offering sugar syrup, but the change from syrup to meat was much

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more difficult, although it happened occasionally. Some wasps attempted to defend a supply of food against other would-be collectors. Despite their wariness of each other, wasps were attracted by the sight of others at a food source. The frequency with which a wasp continues to visit a site that has ceased to yield food depends on its previous foraging experience there.

11.10 FREE, J. B. & WILLIAMS, I. H. (1970) Preliminary investigation on the occupation of artificial nests by *Osmia rufa* L. (Hymenoptera, Megachilidae). *J. appl. Ecol.* **7**, 559–566.

Initial trials indicated that *Osmia rufa* tends to nest at sites it has previously occupied. In some places the number of artificial nests occupied rapidly increased.

11.11 FREE, J. B., WEINBERG, I. & WHITEN, A. (1969) The egg-eating behaviour of *Bombus lapidarius* L. *Behaviour* **35**, 313–317.

When *Bombus lapidarius* workers built egg cells and laid eggs, their queen ate the eggs and appropriated their egg cells for her own eggs, whereupon the workers tried to eat her eggs. The behaviour of the workers was correlated with their ovary development.

11.12 WILDING, N. (1970) *Entomophthora* conidia in the air-spora. *J. gen. Microbiol.* **62**, 149–157.

At Silwood Park, Berkshire, in 1958, the largest concentration of each of five 'types' of *Entomophthora* conidia in the air typically occurred at 05·00 to 07.00 hours B.S.T. and was associated with humid air and sunrise. The concentration was smallest between 14.00 and 17.00 hours B.S.T. when the air was usually driest.

11.13 WILDING, N. (1970) The effect of temperature on the infectivity and incubation periods of the fungi *Entomophthora aphidis* and *E. thaxteriana* for the pea aphid *Acyrthosiphon pisum*. *Proc. IVth Internat. Colloq. Insect Path., College Park, Maryland, U.S.A. Aug. 1970.* (In the press.)

Pea aphids were infected experimentally with *Entomophthora aphidis* and *E. thaxteriana* at temperatures from 5° to 25°C. Although the incubation period of each species shortened as the temperature increased, the fungi may spread most effectively among aphid populations at temperatures below 25°C because the life cycle of the aphid is then comparatively longer than that of the fungi.

Statistics Department

GENERAL PAPERS

12.1 BOYD, D. A. (1970) Multi-level nitrogen tests for cereals. *Prog. Rep. exp. Husb. Fms exp. Hort. Stns N.A.A.S.* No. 11, 38–39. London: H.M.S.O.

12.2 VERNON, A. J. (1971) Canker: the forgotten disease of cocoa. *Cocoa Growers' Bulletin* **16**, 9–14.

RESEARCH PAPERS

12.3 (ALDERMAN, G., MORGAN, D. E.) & LESSELLS, W. J. (1971) A comparison of liveweight gains of beef cattle with values predicted from energy intakes measured as starch equivalent or metabolisable energy. *Proc. 5th Symp. European Assoc. Anim. Prod.* pp. 81–84.

The relative ability of four particular energy systems to predict daily liveweight gain (DLWG) in beef cattle was tested on a large body of results covering a wide range of diets and liveweights. The A.R.C. metabolisable energy system (but with fasting metabolism based on fasted weights assumed to be 90% of liveweight) usually gave the best predictions. The simplification of excluding the plane of nutrition correction increased predicted DLWG by amounts ranging up

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to 0·1 kg, but did not greatly lessen accuracy. Both versions overestimated DLWG with high energy diets. The two versions of the starch equivalent (SE) system tended to underestimate low DLWG and overestimate high DLWG, partly because all predictions were based on only one set of the several SE standards applicable to beef cattle. Inclusion of the T. B. Wood 20% addition to the S.E. values of hays and straw, or the sliding crude fibre correction factor for the SE values of silage, increased and improved the predictions with the mainly forage diets.

12.4 ANDERSON, A. J. B. (1971) Numeric examination of multivariate soil samples. *J. int. Ass. mathl Geol.* **3,** 1–14

Numerical methods for examining multivariate soil samples are presented in geometric terms. Techniques of co-ordinate representation by principal components, by non-metric scaling and by a new method are discussed, as are techniques for agglomerative hierarchical cluster analysis.

12.5 BOYD, D. A. (1971) Some recent ideas on fertiliser response curves. *Proc. Congr. int. Potash Inst.* (In the press.)

In experiments testing many dressings of nitrogen for sugar beet, cereals and potatoes, the typical fertiliser/yield relationship had an almost linear steeply-rising portion with a fairly sharp transition to a second line where yield changed little or slowly decreased. The linearity of this second portion was well-established and, on soils already rich in N, response of all three crops was sometimes wholly on this portion of the response curve; some experiments with cereals and potatoes showed large decreases in yield when too much N was given.

In experiments with P and K, potato yields at first increased almost linearly; beyond a transition point yield was unaffected by further dressings.

The results show the importance of testing enough dressings and of keeping careful records for every site to help identify factors limiting the amount or rate of response.

With cereals and potatoes, grouping the experimental results by soil series and, for N, according to type of crop rotation eliminated much of the differences in response from site to site and so retained the rectilinear relationships of the single experiments; as a result, advice to farmers could be simpler and more precise.

12.6 CHURCH, B. M. (1970) The place of sample survey in crop loss estimation. In: *Crop loss estimation methods*, F.A.O. Manual. Rome: F.A.O.

The uses and limitations of sample surveys in crop loss estimation work are indicated. Requirements for successful surveys and factors influencing the size and type of samples needed are discussed.

12.7 CHURCH, B. M. & (WEBBER, J.) (1971) Fertilizer practice in England and Wales: a new series of surveys. *J. Sci. Fd Agric.* **22,** 1–7.

Aims and methods for a series of surveys in England and Wales begun in 1969 are described. The surveys are designed to monitor changes in practice on individual crops for the whole country and to provide estimates, based on three to four years' data, of practice within regions of defined farming type.

Survey estimates of fertiliser consumption in 1969 agree well with subsidy claims. Between 1966 and 1969, the use of N per acre on tillage crops increased at an average rate similar to that for the previous decade, but the recent increase on grassland was more rapid; use of P and K increased on tillage crops but hardly changed on grassland.

The average manuring of most crops in 1969 was within the range of current general recommendations, but most sugar beet had too much N, P and K per acre. Spring cereals might profit from more N, but the average use of P on winter wheat and of K on potatoes, especially earlies, seems more than adequate.

More N was used on all types of grassland in 1969 than in 1966; increases were greatest on the 15% of the acreage strip grazed or cut for silage. The small proportion of intensively managed grassland increased little between 1966 and 1969.

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For spring barley, leys and permanent grass, comparative estimates are given of average practice in arable, mixed farming, dairying and livestock farming regions.

12.8 GOWER, J. C. (1970) Measures of taxonomic distance and their analysis. *Proc. Symp. Assessment of Biological Affinity and Distance between Human Populations, Utrecht, 1969.* O.U.P. (In the press.)

The distances between populations denoted by *DD* (Czeckanowski), *CRL* (K. Pearson) and D^2 (Mahalanobis) and their inter-relationships are discussed. Variations on these distances are the Penrose size and shape components of *CRL* (C_Q and C_Z) and Hiernaux's Δ_g. All the above measures may formally include quantitative variates and/or proportions. When D^2 is used specifically with proportions and a dispersion matrix derived from the multinomial distribution, we have the distances *B* and *G* of Balakrishnan and Sanghvi, which are contrasted with the angular transformation of proportions used with *CRL* to give *E* of Edwards and Cavalli-Sforza. Distances between individual samples, rather than proportions, may also be estimated by these statistics, but other measures based on dissimilarity coefficients are available too.

Methods of analysis include: (i) those that map optimably the computed distances d_{ij} to a set of points, preferably in few dimensions, with Euclidean distances d^*_{ij}; (ii) those that give a hierarchical representation that can often be thought of as a mapping from d_{ij} to d^*_{ij}, and ultrametric. Hierarchical representations can be used to suggest clusters but direct cluster analysis methods are also discussed.

Methods of comparing two mappings of the same data are discussed in relation to typical anthropometric problems.

12.9 GOWER, J. C. (1970) A note on Burnaby's character weighted similarity coefficient. *J. math. Geol.* **2**, 39–45.

Some of the problems of weighting characters and of eliminating correlational effects between characters are discussed. Many different weighting schemes can be proposed for similarity coefficients even when, as in Burnaby's coefficient, it is decided to give high weight to matches between rare characters. The rarity of a character-state must be considered relative to the sampling scheme used to select the sampling units. Similarities between all pairs of units are often analysed to suggest groups amongst the units. Groups having many correlated characters may be the most useful but are unlikely to be found by numerical methods that eliminate correlational effects.

12.10 GOWER, J. C. (1971) Statistical methods of comparing different multivariate analyses of the same data. *Proc. Congr. R. Soc. Rumanian Acad. Sci. on Mathematical Methods in the Archaeological and Historical Sciences.* (In the press.)

This paper considers how to compare two sets of distances d_{ij} and d^*_{ij} $(i, j = 1, 2, \ldots, n)$ among the same *n* samples. Rather than correlate the 2^n distance pairs (d_{ij}, d^*_{ij}) it is suggested that each set of distances be represented by *n* points p_i, p^*_i $(i = 1, 2, \ldots, n)$ which are rotated to best fit defined by minimising

$$R^2 = \sum_{i=1}^{n} \Delta^2(p_i p^*_i).$$

The mathematical technique required is useful with many different multivariate problems. It is illustrated with a new type of analysis using anthropological data on skulls from six hominoid populations with eight recognisable constellations of characters. A canonical variate analysis for each constellation gives eight sets of canonical variate means and each pair (u, v) is rotated to best fit R^2_{uv}. The elements of the 8×8 symmetric R^2 matrix can themselves be treated as distances and represented by points in three dimensions, allowing examination of how the descriptions of the populations are related when analysed by different constellations of characters. Some of the statistical distributional problems raised by this and similar types of analysis are discussed.

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12.11 GOWER, J. C. & (HILL, I. D.) (1971) Internal data structures. *Appl. Statist.* **20**. (In the press.)

In most computer languages, the data are regarded as being held in machine storage either as individual scalar quantities or as members of rectangular arrays. It would make these languages more useful if the user could specify the shapes of other structures in which he wished to consider the data as being held, such as triangular arrays, trees, etc.

To go with the ability to define structures, the user would require the ability to define operators to act on structures.

12.12 (JOHNSON, E. W.) & HILLS, M. G. (1971) Relationships between soil and plant nutrient status in commercial tomato houses. *Exp. Hort.* (In the press.)

Soil and leaf samples from tomato plants were taken from 105 commercial glasshouses on three occasions in 1967. Means and distributions of nutrients in soils and leaves are given and their relationships examined. Much potassium in the soil inhibited uptake of magnesium and seemed to decrease yield when the soil was deficient in magnesium.

12.13 KRZANOWSKI, W. J. (1971) The algebraic basis of classical multivariate methods. *The Statistician.* (In the press.)

Although the classical multivariate techniques are often taught separately, the basic algebra involved in most of them is very similar. This is because many of these methods arise from the optimisation of a criterion that can be expressed as a quadratic function, or the ratio of quadratic functions, after an *a priori* structure has been imposed on the data matrix. This approach is demonstrated, and some modern computational methods briefly described.

12.14 LEECH, F. B. (1970) Calculation of hypergeometric sample sizes. *Appl. Statist.* **19**, 287–289.

When a sample of n ml from a vaccine batch of N ml is tested for the presence of residual active virus, the probability P of failing to detect a proportion p of infective units, when all n sample units are negative to the test, is given by the first term of the hypergeometric distribution

$$P = \{(N - m)!(N - n)!\}/\{N!(N - m - n)!\},$$

in which $m = Np$. The algorithm obtains values of n corresponding to given values of P, N and $p = m/N$ in this equation, using an iterative method based on the fact that the relation of $\log P$ to $\log (N - n)$ is almost linear.

12.15 NELDER, J. A. (1971) Statistical computing and computer languages. *Appl. Statist.* **20**. (In the press.)

The activities of the Working Party on Statistical Computing are discussed under two headings: (1) The Algorithm Section in Applied Statistics; problems of algorithm construction and testing are described, and illustrated by the formation of a sums-of-squares-and-products matrix from a data matrix. (2) Data structures; the possibility for the statistical programmer of defining and operating on data structures relevant to statistics is not met by commonly available languages. The impending arrival of extensible languages should avoid the need for statisticians to implement special statistical languages, but increases the need for them to standardise their data structures if programs are to be easily used and transferred.

12.16 NELDER, J. A. & (COOPER, B. E.) (1971) Input/output in statistical programming. *Appl. Statist.* **20**. (In the press.)

Input/output (I/O) is analysed in terms of the transfer of items of various types having various internal and external representations between various internal and external positions. Ways of describing representation and position are discussed, for both character and binary data. Three basic properties of good I/O facilities for statistical computing are stated, and the facilities offered by four existing programming languages are matched against them. Finally extensions to Fortran are proposed that would provide the properties sought.

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12.17 (Potato Marketing Board), Rothamsted Experimental Station [Church, B. M. & Hills, M. G.], & (National Institute of Agricultural Engineering) (1970) *Survey of early potatoes*, 1968. Potato Marketing Board Report.

This survey of 374 farms, the first of its kind, covered seven districts specialising in early potatoes and provides information on seed preparation, cultivation and planting, the use of fertilisers, pesticides and herbicides, and on harvesting methods.

About half the early potato acreage was planted with home grown, usually once grown, seed; 80% of the crop was machine planted, but hand planting was common in S. Wales and S.W. Scotland. The average seed rate was 25 cwt/acre (compared with 21 cwt/acre for main crop); 94% of seed was chitted, but only a quarter in buildings with both heating and controlled lighting.

Two-thirds of the crop was treated with herbicide, haulm destroyer was used on half, fungicide on a fifth and insecticide on a tenth of the acreage. Cultivations after planting were needed on 70% of the acreage without herbicide but only on 30% with. Forty-two per cent of early potatoes were lifted by complete harvesting and a third of hand-lifted crops were sold directly off the field.

12.18 (Potato Marketing Board), Rothamsted Experimental Station [Church, B. M. & Hills, M. G.], & (National Institute of Agricultural Engineering) (1970) Survey of main crop potatoes, 1968. Potato Marketing Board Report.

From this survey of 2000 farms, information was obtained on current practice in growing, harvesting and storing main crop potatoes. A similar survey was done in 1963. Major changes between the two surveys were the increased use of special machinery for planting and lifting, and of buildings for storage, and the introduction of selective herbicides for this crop.

In 1968, 92% of the main crop potato acreage was planted by machine (80% in 1963), 40% was lifted by complete harvester (18%) and 70% of the stored crop was stored in buildings (50%). Tests after lifting found rather more sound ware left on fields not lifted by complete harvester.

Herbicides were used on 44%, insecticides on 38% (22% in 1963), fungicides on 63% and haulm destroyers on 70% of the 1968 crop. Fertiliser practice was little changed except that a third had FYM, compared with half the crop in 1963. Cultivations after planting were very few in 1968, because of increased use of herbicides.

12.19 Ross, G. J. S. (1970) The efficient use of function minimisation in non-linear maximum likelihood estimation. *Appl. Statist.* **19**, 205–221.

Maximum likelihood estimation problems can be solved numerically using function minimisation algorithms, but the amount of computing required and the accuracy of the results depend on the way the algorithms are used. Attention to the analytical properties of the model, to the relationship between the model and the data, and to descriptive properties of the data can greatly simplify the problem, sometimes providing a method of solution on a desk calculator. This paper describes how parameter transformation, sequential minimisation and nested minimisation can be used to solve particular problems. Applications to well-known problems of distribution fitting, quantal responses and least-squares curve fitting are described. The implications for computer programming are discussed.

12.20 (Ross, J. M.) & Simpson, H. R. (1971) The National Survey of Health and Development. 1. Educational attainment. *Br. J. educ. Psychol.* **41**, 49–61.

Two measures of educational success are derived from data collected in the National Survey of Health and Development of Children. The first measure is based on the results of tests taken by the children when 15 years old; the second is based on the results of examinations, leaving age and type of employment at 18.

Mathematics and reading tests were the best predictors of school progress.

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12.21 (Ross, J. M.) & Simpson, H. R. (1971) The national survey of health and development. 2. Rate of school progress between 8 and 15 years and between 15 and 18 years. *Br. J. educ. Psychol.* (In the press.)

Using the two measures of educational success developed in the previous paper, various factors influencing the rate of school progress were examined. The education of the parents and the size of the family have a continuing effect on the performance of the child between 8 and 18.

Computer Department

Book

13.1 Yates, F. (1970) Experimental design: selected papers. London: Griffin, xi, 296 pp.

This book contains a collection of the author's more important papers on experimental design with a brief note at the beginning of each paper to put it in historial perspective. A further criticism of fixed and random effects models is also included.

Research Papers

13.2 Yates, F. (1971) Sensitivity: an alternative representation of the power function of a test of significance. In: *Statistical papers in honor of George W. Snedecor.* Ames: Iowa State University Press.

The sensitivity of a test of significance having power P at significance level α is defined as μ_N^2/μ^2 where μ and μ_N are the departures from the null hypothesis for power P of the test and the corresponding unit normal deviate test. Values of the sensitivity of the t test with 4, 6, 9, 16 degrees of feedom are given for a range of P and α: the sensitivity decreases greatly for small α but does not vary greatly with P. The results of a Monte-Carlo investigation of the efficiency of the combination of probabilities test are also reported in terms of sensitivity.

13.3 Yates, F. (1971) Variable format in Fortran. *Appl. Statist.* (In the press.)

Standard Fortran does not provide explicitly for format statements containing parameters whose values are determined at run-time. Formats can, however, be held in arrays. These can either be read at run-time or elements of them can be altered at run-time. The present routine provides a convenient method of making such alterations. Thus, for example, tables can be printed with a variable number of blocks across the page and a variable number of columns in a block.

Field Experiments Section

Research Paper

14.1 Garner, H. V. (1970) Experiments with kiln-dried poultry manure on agricultural crops and vegetables at Rothamsted, Woburn and other centres in 1933–39. *Expl Husb.* **19**, 13–28.

The value of the N of dried poultry manure was compared with that of ammonium sulphate in 148 field experiments done during the period 1933–39. In 11 of these experiments the P of poultry manure was tested against superphosphate. The dried poultry manure as used contained on the average: dry matter 85·9%, N 3·6%, P_2O_5 3·6%, K_2O 1·8%. When the N comparison was made at one rate only (60 units N per acre) the ammonium sulphate equivalent of poultry manure was 51% in 41 experiments in potatoes, 65% in 20 experiments with kale and 75% in four experiments with mangolds. When each manure was tested at 40 and 80 units N the sulphate of ammonia equivalents were: potatoes 50% at each rate of N; brussels sprouts 58% at 40 units and 43% at 80 units; kale 17% and 28%; swedes 40% and 15%.

Crops for which poultry manure was on the average equal to or better than sulphate of ammonia were sugar beet, red beet, early potatoes, French and runner beans, broccoli and

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vegetable marrows. The experiments with vegetable crops were few and more are needed with these crops that seem to respond especially well to poultry manure. There was a strong and consistent negative interaction between poultry manure and ammonium sulphate when given together.

The P value of poultry manure was not well determined because the P responses were usually small, but on a P-deficient boulder clay soil brussels sprouts responded much better to poultry manure alone than to ammonium sulphate alone. There was a negative interaction between poultry manure and superphosphate on this soil.

Ammonium sulphate and superphosphate used together almost always gave larger yields than poultry manure containing the same amount of N and P. When light dressings (11 cwt/acre) of poultry manure were repeated for several seasons the cumulative effects were small. The residual effect from 22 cwt of dried poultry manure for a second crop was not consistently better than from an equivalent dressing of ammonium sulphate.

Farm

15.1 MOFFATT, J. R. (1971) Long-term effects of cultivations. *J. Proc. Instn agric. Engrs.* **25**, 161–165.

Broom's Barn Experimental Station

General Papers

16.1 COOKE, D. A. (1970) The control of ectoparasitic nematodes of sugar beet in Britain. *Proc. 10th International Symposium of European Nematologists, 1970*, 146–147.

16.2 DRAYCOTT, A. P. (1970) The need for magnesium by sugar beet. *Pertwee Report*, Spring 1970, p. 13.

16.3 DRAYCOTT, A. P. & DURRANT, M. J. (1970) Magnesium fertilisers for sugar beet (Part II). *Br. Sug. Beet Rev.* **38**, 175–180.

16.4 DUNNING, R. A. (1970) What to do about Docking disorder. *Arable Farmer*, February 1970.

16.5 HEATHCOTE, G. D. (1970) Caddis flies. *Trans. Suffolk Nat. Soc.* **15**, 219–221.

16.6 HEATHCOTE, G. D. (1971) Weeds, herbicides and plant virus diseases. *Proc. 10th British Weed Control Conference, 1970*, **3**, 934–941.

Paper in Rothamsted Report, Part 2

16.7 WHITEHEAD, A. G., DUNNING, R. A. & COOKE, D. A. (1971) Docking disorder and root ectoparasitic nematodes of sugar beet. *Rep. Rothamsted exp. Stn for 1970*, Part 2, 219–236.

Ectoparasitic nematodes, especially species of *Trichodorus* (stubby root nematodes) and *Longidorus* (needle nematodes), feed on and damage the root tips of sugar beet; Docking disorder is the poor growth of sugar beet resulting from this primary damage. Yield loss does not depend only on the number of nematodes in the soil, but also on other interacting factors, especially soil structure and rainfall, which affect the numbers and activity of the nematodes, the nutrients available to the seedlings and the vigour of root growth. Modern cultural practices, especially the use of herbicides and drilling to a stand, probably increase the prevalence and severity of Docking disorder. Approximately 20 000 acres of sugar beet suffered from Docking disorder in 1969, at an estimated yield loss exceeding 50 000 tons of roots.

Damage can be alleviated by correct use of nitrogen, principally by avoiding leaching or

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replacing the nitrogen lost by leaching, and it can be prevented by nematicides. Fumigating all the top soil with 'D-D' or 'Telone' kills nearly all the nematodes and greatly increases the yield of sugar beet and other crops in the rotation, but is expensive. Small amounts of fumigant or systemic nematicides applied to the sugar-beet rows at or before sowing kill most of the nematodes in the rows, or prevent them from feeding on the roots, allowing the seedlings to grow vigorously, and can greatly increase yield.

Research Papers

16.8 Byford, W. J. (1970) Experiments on the effect of plant losses after singling on the yield of sugar beet. *Pl. Path.* **19**, 169–171.

Removing alternate plants from sugar-beet crops during the first week of either June, July or August decreased sugar yields by 5, 16 and 33% and removing alternate pairs of plants, by 10, 19 and 35% respectively. This must be taken into account when estimating crop-yield losses from yield losses suffered by single infected plants.

16.9 Byford, W. J. & (Carter, S.) (1970) Myxomycetes on beet seed. *Trans. Br. mycol. Soc.* **55**, 316–318.

Didymium iridis (Ditmar) Fr. and *Diderma deplanatum* Fr. were found frequently on beet seed samples from England, Italy and U.S.A., and *D. deplanatum* on a sample from France. *Didymium trachysporum* G. Lister, was found on two samples from Italy.

16.10 (Boyd, A. E. W., Erskine, D. S. C.), Byford, W. J. & Webb, D. J. (1970) A herbicide induced abnormality in sugar-beet. *Pl. Path.* **19**, 163–164.

A twisting of the root below ground level, sometimes so severe as to break the root, was found in Scotland and England in 1966 and 1967 in sugar-beet crops grown in soil treated with herbicides, principally, but not exclusively, propham. The abnormality was most severe when the herbicide was worked into the soil either after or immediately before drilling.

16.11 Draycott, A. P. (1971) Fertiliser requirements of sugar beet on peaty mineral and organic mineral soils. *Expl. Husb.* (In the press.)

Eighteen experiments (1966–69) were made on peaty mineral and organic mineral soils to test the fertiliser requirement of sugar beet. All were on commercial farms round the Wash and tested nitrogen (0, 0·6 and 1·2 cwt/acre N), phosphate (0, 0·75 and 1·50 cwt/acre P_2O_5), potash (0, 1·00 and 2·00 cwt/acre K_2O) and agricultural salt (0 and 1·2 cwt/acre Na) in a factorial design.

On average, 0·6 cwt/acre N, 0·75 cwt/acre P_2O_5 and no salt or potash gave near-maximal yield. There was no important interaction between the four elements. The effects of the fertilisers on individual fields differed widely, both in the magnitude of their effect on yield and in the amount needed for maximal yield. On a few fields the crop needed 1·2 cwt/acre N, and a few crops needed 1·50 cwt/acre P_2O_5, but none responded significantly to potash or salt.

16.12 Draycott, A. P. & Durrant, M. J. (1971) Effects of nitrogen fertiliser, plant population and irrigation on sugar beet. Part II. Nutrient concentration and uptake. *J. agric. Sci., Camb.* **76**, 269–275.

The concentrations of nitrogen, phosphorus, potassium, sodium, calcium and magnesium was measured in the dry matter of sugar beet from four field experiments (1966–69). All combinations of four amounts of nitrogen fertiliser (0–1·8 cwt/acre), four plant populations (8800–54 000 plants/acre) and irrigation were tested, which gave a wide range of plant size and yield. Nutrient concentration and uptake by the crop were also greatly affected by the treatments.

Nitrogen fertiliser and irrigation increased uptake of nitrogen by the crop but increasing the plant population had little effect on uptake and decreased the concentration of nitrogen. Sugar yield was related to the total nitrogen concentration in tops and roots and to uptake. There

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were optimal values of nitrogen concentration for maximal sugar yield, but the optima were greatly affected by plant population. Leaf colour was a good guide to nitrogen concentration.

Phosphorus concentration was affected little by the treatments but cation concentrations were greatly affected. In general, uptake of all the elements was increased by all treatments—the exception was sodium, which decreased as the plant population increased but this was balanced to some extent by increased potassium uptake.

16.13 DRAYCOTT, A. P. & DURRANT, M. J. (1971) Effects of nitrogen fertiliser, plant population and irrigation on sugar beet. Part III. Water consumption. *J. agric. Sci., Camb.* **76,** 277–282.

A neutron moderation meter was used to measure soil moisture 0–4 ft deep in plots of sugar beet carrying two plant populations (8800 and 54 000 plants/acre), each with and without irrigation. Recordings began in April or May in each of three years (1967–69) after sowing the crop, and continued at one- or two-week intervals until harvest in October.

The measured soil moisture deficits were very similar to potential deficits calculated from meteorological measurements. This indicates that the crop could extract the water needed for transpiration from the soil even when the deficits were quite large (more than 5 in. in 1967), which probably explains the small response to irrigation by sugar beet in England.

When the soil moisture deficit increased rapidly early during the season (1967), the crop extracted water from the soil by exhausting the available water from progressively deeper horizons, whereas when the deficit increased rapidly late during the season (1969), water was still being extracted from all horizons until harvest. Both decreasing the plant population and irrigating decreased the amount of water used from depth in the profile every year.

The total amount of water used (evaporation plus transpiration), on average, from soil reserves and rainfall, was 12·2 in. by the small population and 13·4 in. by the large population. When irrigated, the consumption increased to 14·2 in. and 15·4 in. respectively. The difference in usage between populations was almost entirely from the difference in leaf cover early during the season. The water consumption in 1968, when the summer was wet, was only two-thirds of that in 1967 and 1969 when the summers were drier.

16.14 DRAYCOTT, A. P., HULL, R., MESSEM, A. B. & WEBB, D. J. (1970) Effects of soil compaction on yield and fertiliser requirement of sugar beet. *J. agric. Sci., Camb.* **75,** 533–537.

Five experiments (1967–69) on soils formed from calcareous drift examined the effects of soil compaction on seedling emergence and yield of sugar beet, also the interaction between compaction and response to nitrogen fertiliser (N) and phosphate fertiliser (P_2O_5). Some seedbeds were compacted in winter, others in spring, and others prepared with the minimum of compaction; each was tested with 0·6, 1·2 and 1·8 cwt/acre N plus 0·8 cwt/acre additional P_2O_5. All plots were given a basal dressing of 0·8 cwt/acre P_2O_5 and enough of other major nutrients.

Compaction decreased seedling populations in four experiments but increased it in one year, when the weather was dry while the seeds were germinating. However, in every experiment compaction significantly decreased yield of roots and sugar. It also interacted with the fertiliser treatments, significantly on average, increasing nitrogen requirement and decreasing phosphate requirement. On average, 0·6 cwt/acre N and 1·6 cwt/acre P_2O_5 gave the greatest yield without compaction and 1·2 cwt/acre N and 0·8 cwt/acre P_2O_5 with compaction.

16.15 DRAYCOTT, A. P. & LAST, P. J. (1971) Some effects of partial sterilisation on mineral nitrogen in a light soil. *J. Soil Sci.* **22.** (In the press.)

Field plots on loamy sand with and without soil fumigant 'D-D' (dichloropropane-dichloropropene mixture) were sampled at 0–12, 12–24, and 24–64 cm depths during May 1966–68. All plots received 125 kg/ha nitrogen fertiliser early in March each year and were cropped with sugar beet. Fumigation increased the total amount of mineral ($NH_4^+ + NO_3^-$) nitrogen to a depth of 64 cm by 67 kg/ha on average, largely by increasing NH_4^+-nitrogen. In unfumigated plots

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some mineral nitrogen leached below 12 cm every year but there was at least 125 kg/ha in the surface 64 cm in 1966 and 1968; during the wet spring of 1967 much leached below 64 cm. Sequential sampling in 1968 confirmed that some of the fertiliser nitrogen moved down the profile during spring.

Plots partially sterilised either one or two years previously and not again, contained the same quantity of mineral nitrogen as plots that had never been fumigated. Fumigation increased the mineral nitrogen in plots by a similar amount whether or not they had been fumigated previously. Thus, on this soil, partial sterilisation with 'D-D' seemed to have little residual effect on mineral nitrogen.

16.16 DRAYCOTT, A. P. & WEBB, D. J. (1971) Effects of nitrogen fertiliser, plant population and irrigation on sugar beet. Part I. Yields. *J. Agric. Sci., Camb.* **76,** 261–267

Five experiments (1965–69) on calcareous sandy loam tested all combinations of four amounts of nitrogen (0–1·8 cwt/acre N) with four plant populations (7000–54 000 plants/acre) given to sugar beet grown with and without irrigation. On average, nitrogen and plant population influenced yields greatly but irrigation relatively little. In all years, between 0·6 and 1·2 cwt/acre N and between 17 000 and 32 000 plants/acre gave largest sugar yield. Giving more nitrogen or increasing the plant population neither increased nor decreased sugar yield much in any year. Irrigation was beneficial in only two out of five years.

Sugar yield was linearly related to root dry-matter yield. Although total dry matter was greatest when the largest plant population was given the largest dressing of nitrogen and irrigation, the proportion of dry matter in the roots was decreased by all three factors.

16.17 HEATHCOTE, G. D. (1970) Effect of pelleting sugar-beet seed with menazon. *I.I.R.B.* (*J. Inst. Sugar Beet Res.*) **5,** 42–51.

Menazon powder was incorporated with sugar-beet seed pelleted by the 'Filcoat' process. Although in the glasshouse more seedlings grew from menazon-treated pellets sown in heat-treated compost than from untreated pellets, in the field often fewer seedlings emerged. On average, the population of green and of black aphids was twice as large during June on plants grown from seed pellets without menazon as on those from menazon-treated pellets, but aphid populations differed little during July. Virus yellows did not spread widely in 1968 or 1969 and treating seed by pelleting with menazon did not limit the late spread of yellows.

16.18 HEATHCOTE, G. D. (1970) Effect of plant spacing and time of sowing of sugar beet on aphid infestation and spread of virus yellows. *Pl. Path.* **19,** 32–39.

Aphid infestation and incidence of plants with virus yellows in sugar-beet crops at Broom's Barn Experimental Station from 1964–68 differed greatly with changes in densities of stand ranging from 8000 to 68 000 plants/acre (0·4 ha), and with changes in sowing date. The numbers of *Myzus persicae* and of *Aphis fabae* infesting beet during June and July, the numbers of virus-infected plants/unit area, and the percentages of plants with yellows usually decreased as the plant population increased, but usually increased with delay in sowing from mid-March to early May.

16.19 HEATHCOTE, G. D. (1970) The abundance of grass aphids in eastern England as shown by sticky trap catches. *Pl. Path.* **19,** 87–90.

The numbers of several species of grass aphids caught on cylindrical sticky traps at Rothamsted Experimental Station from 1942–46 and from 1951–59, and at Broom's Barn Experimental Station from 1960–69 are given. Some of the species were attracted to yellow traps; others are not strongly attracted to yellow but are impacted by the wind on sticky traps. *Macrosiphum avenae* and *Metopolophium dirhodum* were exceptionally abundant at Rothamsted in 1968. *M. avenae* was also exceptionally abundant at Broom's Barn in 1968, but the largest catch there of *M. dirhodum* was in 1961.

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16.20 HULL, R. & WEBB, D. J. (1970) The effect of sowing date and harvesting date on the yield of sugar beet. *J. agric. Sci., Camb.* **75**, 223–229.

A field experiment in each year 1963 to 1967 in Suffolk, England, tested the effect on yield of sugar beet of sowing dates ranging from 13 March to 11 May and harvest dates ranging from 20 September to 8 December. Sowings in March or early April gave similar yields of sugar but with later sowings yield decreased progressively faster. The relationship is represented by the equation

$$y = 106{\cdot}3\ (\pm 2{\cdot}23) + 0{\cdot}212\ (\pm 0{\cdot}184)x - 0{\cdot}009\ (\pm 0{\cdot}003)x^2,$$

y = yield as percentage of mean (60·1 cwt/acre of sugar), x = number of days after 12 March. Delayed harvest increased sugar yield; the relationship is represented by the equation

$$y = 80{\cdot}22\ (\pm 1{\cdot}51) + 0{\cdot}836\ (\pm 0{\cdot}09)z - 0{\cdot}006\ (\pm 0{\cdot}001)z^2,$$

z = number of days after 19 September. This represents an increase of 0·247 cwt/acre/day of sugar in October and 0·083 cwt/acre/day in November, equivalent to about $2\frac{1}{2}$ tons/acre of roots in October and 1 ton/acre in November.

The effect on sugar yield of different lengths of growing period, which ranged from 138 to 271 days, is presented by the equation

$$y = 38{\cdot}7\ (\pm 26{\cdot}6) + 1{\cdot}045\ (\pm 0{\cdot}267)a - 0{\cdot}0017\ (\pm 0{\cdot}0007)a^2,$$

a = number of days between sowing and harvest.

On average, sowing date had negligible effect on sugar percentage at harvest. In 3 years sugar percentage increased after the first harvest to a maximum and then decreased; in 2 years it decreased with consecutive harvests.

16.21 LONGDEN, P. C., JOHNSON, M. G. & LOVE, B. (1970). Sugar-beet seedling emergence prediction from radiographs. *J. int. Inst. Sugar Beet Res.* (In the press.)

Equipment designed to speed the radiography of monogerm sugar-beet seeds is illustrated and the technique of radiography described. Results from six experiments, with a total of about 12 000 seeds, show that assessment of the radiographs could be used to predict seedling emergence such that when all results were plotted, seedling emergence (y) seemed to be linearly related to radiograph prediction (x), and the equation of best fit was $y = 0{\cdot}88x - 4{\cdot}22$ (correlation coefficient 0·65 with 95 d.f.), in which the extreme values of x encountered were 49 and 92%. The relationship between seedling emergence (y) and laboratory germination test predictions (x) was also linear with the equation of best fit given by $y = 0{\cdot}94x + 0{\cdot}72$ (correlation coefficient 0·73 with 95 d.f.), in which extreme values of x were 29 and 79. Radiograph predictions of emergence were therefore almost as accurate as standard laboratory germination tests and took only 2 hours instead of 15 days to complete. The consistent overestimation of emergence by radiograph assessment was examined by recovering failed seeds and dissecting them. Most appeared sound and the importance of seed dormancy is being investigated. Radiograph prediction (x) of standard germination test (y) was quite good, and the linear regression equation of best fit was $y = 0{\cdot}57x + 20{\cdot}9$ (correlation coefficient 0·79 with 95 d.f.).

16.22 SCOTT, R. K. (1970) The effect of weather on the concentration of pollen within sugar-beet seed crops. *Ann. appl. Biol.* **66**, 119–127.

The concentration of pollen in the air within diploid open-pollinated sugar-beet crops at Broom's Barn Experimental Station increased between 05.00 and 09.00 G.M.T. as relative humidity became less than 90%, was greatest between 09.00 and 11.00 when relative humidity was *c.* 75%, and gradually decreased towards evening. The average pollen concentration during 24 hour periods ranged from 170 to 12 400/m^3 and were greatest on fine, windy, dry days after periods of cooler weather. Rain during the morning washed pollen out of the air and damaged developing anthers, but rain in the late afternoon following a sunny morning seemed hardly to affect the pollen catch, whereas rain at night sometimes caused an immediate temporary increase in pollen concentration. Most pollen was released between 27 June and 31 July in all years (1965–67); more in the first than in the second half of July. 1965 was cool and damp, 1967 warm and dry,

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1966 warm and dry early and cool and wet late. The total pollen catch in 1965 was 83% and in 1966 31% of that in 1967, but the percentage germination of seed harvested in the 3 years was similar.

The total pollen catch on a trap 230 m east of the 1965 crop was *c.* 1% of the catch within the crop on days with gusty westerly winds and the catch on a trap *c.* 46 cm above the 1966 crop averaged 78·6% of that at the level of most flowers.

16.23 SCOTT, R. K. & LONGDEN, P. C. (1970) Pollen release by diploid and tetraploid sugar-beet plants. *Ann. appl. Biol.* **66**, 129–135.

Pollen released during three summers at Broom's Barn, Suffolk, by diploid and tetraploid multigerm sugar-beet plants was caught by automatic volumetric spore traps and by glass funnels situated in the crop. Tetraploids produced on average 66% as much pollen as diploids, their pollen grains were larger and they needed drier air to release pollen, the concentration of which increased more slowly early in the day and was particularly small on dull, damp days. Pollen catches from diploids and tetraploids decreased at a similar rate with increasing distance from the pollinators. The germination of fruits harvested from male-sterile plants among the pollinators was consistently less with a tetraploid than with a diploid pollinator, but was not affected by distance of the male-sterile plants from either pollinator.

Soil Survey

BOOKS

17.1 CROMPTON, A. & MATTHEWS, B. (1970) *Soils of the Leeds district.* Harpenden: Rothamsted Experimental Station, viii, 221 pp.

17.2 CORBETT, W. M. & TATLER, W. (1970) *Soil in Norfolk, Sheet TM 49 (Beccles North).* Harpenden: Rothamsted Experimental Station, viii, 129 pp.

17.3 HALL, B. R. & FOLLAND, C. J. (1970) *Soils of Lancashire.* Harpenden: Rothamsted Experimental Station, *x*, 179 pp.

17.4 RUDEFORTH, C. C. (1970) *Soils of North Cardiganshire.* Harpenden: Rothamsted Experimental Station, viii, 153 pp.

17.5 *Micromorphological techniques and applications* (1970) (Ed. D. A. Osmond & P. Bullock). Harpenden: Rothamsted Experimental Station, 110 pp.

GENERAL PAPERS

17.6 AVERY, B. W. (1969) Problems of Soil Classification. In: *The soil ecosystem*, Ed. J. G. Sheals. *The Systematics Association Publication* No. 8, 9–15.

17.7 BULLOCK, P. & MACKNEY, D. (1969) Clay translocation in soils. Rep. Welsh Soils Discussion Group No. 10, 13–17.

17.8 COPE, D. W. (1969) Soil Survey of Long Ashton Research Station. *Rep. Long Ashton Res. Stn for 1969*, 170–184.

17.9 HALL, B. R. (1968) The lowland peats of Lancashire. *Proc. North of England Soils Discussion Group* No. 4, 5–12.

17.10 HALL, B. R. (1968) Report on a field meeting in south-west Lancashire. *Proc. North of England Soils Discussion Group* No. 4, 25–36.

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17.11 MACKNEY, D. (1969) The agronomic significance of soil mapping units. In: *The soil ecosystem*, Ed. J. G. Sheals. *The Systematics Association Publication* No. 8, 55–62.

17.12 MATTHEWS, B. (1969) The soils of the York district. *Proc. North of England Soils Discussion Group* No. 5, 1–11.

17.13 MATTHEWS, B. (1969) Report on a field meeting in the Vale of York. *Proc. North of England Soils Discussion Group* No. 5, 29–47.

17.14 THOMASSON, A. J. & AVERY, B. W. (1970) The soils of Hertfordshire. (*Spec. Surv. Soil Surv.* No. 3.) Harpenden: Rothamsted Experimental Station.

17.15 WEBSTER, R. (1969) Aerial photography in soil and land survey. *Rep. Welsh Soils Discussion Group* No. 10, 49–54.

17.16 WEBSTER, R. (1970) Soils. In: *The Evergreen forests of Malawi.* Commonwealth Forestry Institute, Oxford.

17.17 WEBSTER, R. (1970) Terrain classification and evaluation using air photography: a review of recent work at Oxford. *Photogrammetria* **26**, 51–75.

RESEARCH PAPERS

17.18 BULLOCK, P. & MACKNEY, D. (1970) Micromorphology of strata in the Boyn Hill Terrace deposits, Buckinghamshire. In: *Micromorphological techniques and applications.* (*Tech. Monogr. Soil Surv.* No. 2.) Rothamsted Experimental Station, pp. 97–105.

The petrographic characteristics and origin of lamellae and interlamellae, differing from each other in clay and iron content, are discussed.

The relative parts played by pedogenic and geological processes in the formation of strongly oriented argillans around skeleton grains in both lamellae and interlamellae are examined. Field evidence suggests a geological origin for some lamellae, whereas pedogenic clay illuviation is a possible factor in the formation of others with similar micromorphological properties.

17.19 CLAYDEN, B. (1970) The micromorphology of ochreous B horizons of sesquioxidic brown earths developed in Upland Britain. In: *Micromorphological techniques and application.* (*Tech. Monogr. Soil Surv.* No. 2.) Harpenden: Rothamsted Experimental Station, pp. 53–67.

The micromorphology of the B horizons of sesquioxidic brown earths is described with special reference to three representative profiles. The fabrics are of two kinds. The first is a very vughy, intertextic fabric, composed of very fine, rounded blocky primary peds, and closely resembles the diagnostic fabric of crumbly spodic horizons. The s-matrix is characteristically silasepic. The second is a less porous porphyroskelic fabric lacking pellet-like primary peds and normally has a sepic s-matrix; it conforms closely to the fabric of a cambic horizon. The porphyroskelic fabrics are associated with soils of fine texture. Subdivision of the soils based on the micromorphology of the B horizons, however, is not supported by criteria based on field morphology or chemical analysis.

17.20 (CUANALO de la C., H. E.) & WEBSTER, R. (1970) A comparative study of numerical classification of soil profiles in a locality near Oxford. Pt. 1. Analysis of 85 sites. *J. Soil Sci.* **21**, 340–352.

Data for 85 soil profiles, taken at random within 17 physiographic units in a 1000 km² area near Oxford, and each characterised by 37 properties, were analysed by two sets of multivariate techniques. Principal component analysis yielded two components accounting for 44% of the

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total variation, and the distribution of the profiles along these components is plotted as a scatter diagram (ordination). Similarity analysis and hierarchical grouping (classification) were performed using three different similarity indices, two different standardisation techniques, and three different sorting strategies. Before analysis the profiles were classified by two pedologists, independently using their judgement.

For the brown earths there was moderately good agreement between the results of the two earlier classifications and between them and those produced by the several numerical procedures. The degree of clustering was slight and much less than imagined before analysis. For the gleys soils there was no evident clustering. Different numerical procedures gave different results, as also did the two earlier classifications. Pedologists faced with difficult classificatory decisions cannot look to any hierarchical clustering strategy as arbiter, though they should get guidance from a principal component plot.

17.21 (EDMONDS, D. T., PAINTER, R. B.) & ASHLEY, G. D. (1970) A semi-quantitative hydrological classification of soils in north-east England. *J. Soil Sci.* **21**, 257–264.

Multiple regression equations relating the times-to-peak of flood hydrographs on 26 rivers in N.E. England with the characteristics of causative rainfall and those of the relevant river basin, showed flood-wave formation to depend largely on storm duration and the average minimum infiltration rate of the soil. Other significant factors were the initial flow in the river, temporal variation of rainfall during a storm, and main river channel length and slope.

17.22 GREENE-KELLY, R. & MACKNEY, D. (1970) Preferred orientation of clays in soils: the effect of drying and wetting. In: *Micromorphological techniques and applications.* (*Tech. Monogr. Soil Surv.* No. 2.) Harpenden: Rothamsted Experimental Station, pp. 43–52.

The origin of the optically birefringent oriented clay observed in sections of many fine-textured soils is briefly discussed. Experiments designed to evaluate the effect of drying and wetting remoulded clay soils on the orientation of clay particles showed no significant change in orientation.

17.23 MATTHEWS, B. (1970) Age and origin of aeolian sand in the Vale of York. *Nature, Lond.* **227**, 1234–6.

Sand deposits within the area of glacial Lake Humber and north of the Escrick moraine were studied. The evidence suggests that they are aeolian and originally deposited during the later part of the Weichselian glacial stage and early Flandrian time when vegetation was sparse and the ground partly frozen. It is largely these areas, and some of morainic fine sands, that now blow.

17.24 RUDEFORTH, C. C. (1969) Quantitative Soil Surveying. *Rep. Welsh Soils Discussion Group* No. 10, 42–47.

Soil properties are recorded at regular (grid) intervals, then related quantitatively to land units derived mainly from air photographs and geological maps. The advantages of the technique over conventional survey methods are illustrated with reference to two 1 : 25 000 sheets in Pembrokeshire.

17.25 RUDEFORTH, C. C. (1970) The micromorphology of surface-water gley soils. In: *Micromorphological techniques and applications.* (*Tech. Monogr. Soil Surv.* No. 2.) Harpenden: Rothamsted Experimental Station, pp. 69–81.

Surface-water gley soils have lower horizons of fine texture, close-packed medium texture, medium or coarse texture with clay filled interstices, or of material made impervious by a chemical precipitate. These horizons restrict water movement and cause gleying above and often within themselves.

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The microfabrics of the restricting layers and overlying gleyed horizons are described with particular reference to matrix colour, cutans, glaebules and voids. Argillans indicate clay movement in many surface-water gley soils. Glaebules are often more diffuse in gleyed than ungleyed horizons. These features, and colour contrast in void cutans, aid horizon classification.

17.26 RUDEFORTH, C. C. & THOMASSON, A. J. (1970) Hydrological properties of soils in the River Dee Catchment. (*Spec. Surv. Soil Surv.* No. 4.) Harpenden: Rothamsted Experimental Station.

A field and laboratory study of soils, occupying 1000 km² of the Catchment above Erbistock in Denbighshire, giving soil hydrologic information useful in planning improvements in water control and supply.

MAPS

17.27 HALL, B. R. & FOLLAND, C. J. (1970) Soil Association Map of the County of Lancashire. 1 : 250 000, Southampton: Ordnance Survey.

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