ROTHAMSTED RESEARCH

Report for 1973 - Part1

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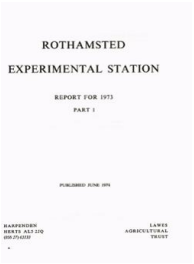

Abstracts of Rothamsted Papers

Rothamsted Research

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ABSTRACTS OF PAPERS

https://doi.org/10.23637/ERADOC-1-130

ROTHAMSTED REPORT FOR 1973, PART 1

Physics Department

General Papers

1.1 Penman, H. L. (1973) The catchment area of the Institute. (A survey of research problems in British hydrology). *Institute of Hydrology, Wallingford, Report No. 20*, 1–15.

1.2 Penman, H. L. (1973) The water cycle. In: *Chemistry in the Environment*. San Francisco: W. H. Freeman. (Reprint of article in *Scientific American*, **223**, 99–108, 1970.

Paper in Rothamsted Report, Part 2

1.3 Penman, H. L. (1974) Rothamsted weather. *Rothamsted Experimental Station. Report for 1973*, Part 2, 172–201.

Research Papers

1.4 Parkinson, K. J., Penman, H. L. & Tregunna, E. B. (1974) Growth of plants in different oxygen concentrations. *Journal of Experimental Botany* **25**, 132–146.

Dwarf french beans (*Phaseolus vulgaris* var. Canadian Wonder) were grown in chambers at 25°C with the roots aerated at 20% oxygen and tops variously maintained at: T_1; O_2 0·21; CO_2 270 × 10^{-6}: T_2; O_2 0·05, CO_2 270 × 10^{-6}: T_3; O_2 0·21; CO_2 550 × 10^{-6}. Experiment 1 (T_1 and T_2) lasted 2 weeks: Experiment 2 (T_1, T_2 and T_3) only one week. Hourly estimates of CO_2 uptake were made by gas analysis and weekly estimates of fresh weight, dry matter in tops and roots, and leaf area, by sampling. Light intensity was 80 W m^{-2} of photosynthetically active radiation.

An attempt was made to explain the results in terms of a simple light absorption model such that

$$dv/dt = \beta I_0 e^{-fL},$$

where dv/dt is the rate of CO_2 uptake per plant, β is the photosynthetic efficiency, I_0 is the incident light intensity, f is the fraction of incident light absorbed by unit leaf layer and L is the leaf area index. The analysis showed that $\beta(T_2)$ was at least double $\beta(T_1)$, whilst $f(T_2)$ was smaller than $f(T_1)$ at a given leaf area. The results also required that throughout the period of the experiment, $fL(T_1) = fL(T_2)$ at any given time, i.e. the treatment with the larger leaf area (T_2) has the smaller value of f, and therefore intercepts less light per unit leaf area. This could be advantageous for plant growth, but requires further experiments.

1.5 Rose, D. A. (1973) Some aspects of the hydrodynamic dispersion of solutes in porous materials. *Journal of Soil Science* **24**, 284–295.

The paper reviews some quantitative aspects of the hydrodynamic dispersion of solute that occurs under the combined influence of molecular diffusion and convection when a solution flows through a porous material. In particular, the paper (i) describes several methods of analysing the breakthrough curve of one solution as it displaces another from a column of porous material to yield a coefficient of hydrodynamic dispersion (K); (ii) discusses the form of K as a function of particle size and fluid velocity in granular beds composed of solid particles or of aggregates; (iii) discusses the effect of K on the dispersion observed in a column of porous material, as fluid velocity and particle size vary, as an aid in assessing the efficiency of leaching.

1.6 (Wetselaar, R., Passioura, J. B.) Rose, D. A. & (Jakobsen, P.) (1973) Banding nitrogen fertilisers in soil: principles and practices. *Chemie et Industrie—Genie Chimique* **106**, 567–572.

The chain of events which occurs when solid nitrogen fertilisers are banded in soil is discussed with reference to detailed laboratory and field experiments. The object is to predict the best way of applying fertiliser to a crop, taking into account the growth of the crop and the effect of the fertiliser on the environment.

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Chemistry Department

Theses

2.1 Holford, I. C. R. (1973) Phosphate adsorption by soils and its relationship to soil properties and plant availability. Ph.D. Thesis, University of London.

2.2 Le Mare, P. H. (1973) The effects of monocalcium phosphate on crops grown in some Buganda soils. Ph.D. Thesis, University of London.

General Papers

2.3 Benzian, B. & Smith, H. A. (1973) Nutrient concentrations in healthy nursery-grown seedlings and transplants of conifers. *Report on Forest Research* (*London*) *1973*, pp. 143–144.

2.4 Cooke, G. W. (1973) It pays to treat pastures well. *Dairy Farmer* October 1973, 40–41.

2.5 Cooke, G. W. (1973) The present and future use of fertilisers on grass. *The George Scott Robertson Memorial Lecture. The Queen's University of Belfast.*

2.6 Cooke, G. W. (1974) Soils and fertilisers. *Journal of the Royal Agricultural Society of England* **134**, 101–113.

2.7 Cooke, G. W. & Williams, R. J. B. (1973) Significance of man-made sources of phosphorus: fertilisers and farming. The phosphorus involved in agricultural systems and possibilities of its movement into natural water. *Water Research* **7**, 19–33.

2.8 Gasser, J. K. R. (1973) An assessment of the importance of some factors causing loss of lime from agricultural soils. *Experimental Husbandry* **25**, 86–95.

2.9 Talibudeen, O. (1974) The nutrient potential of the soil. *Soils and Fertilizers* **37**, 41–45.

Papers in Rothamsted Report, Part 2

2.10 Benzian, B. & Freeman, S. C. R. (1974) Reference Experiments on young conifers at Woburn Experimental Farm, 1961–69. *Rothamsted Experimental Station. Report for 1973*, Part 2, 152–171.

Growth and nutrient uptake of conifer seedlings on land previously under arable cropping were compared for nine years with the behaviour of nearby agricultural crops and with conifers in two research nurseries. Growth of conifers at Woburn was increased by N in wet seasons; K and Mg increased growth only after several years of cropping. P fertilisers gave larger increases in growth of conifers than of agricultural crops. In a five-year experiment slow-release fertilisers were more effective than soluble salts.

2.11 Johnston, A. E. & Mitchell, J. D. D. (1974) The behaviour of K remaining in soils from the Agdell Experiment at Rothamsted, the results of intensive cropping in pot experiments and their relation to soil analysis and the results of field experiments. *Rothamsted Experimental Station. Report for 1973*, Part 2, 74–97.

The amounts of K in the surface soils of the Agdell Experiment in 1967 depended on cropping and manuring between 1848 and 1951, on arable/fallow or grass cropping during 1958–66, and on large dressings of K fertiliser, 261, 522 and 1043 kg K/ha given in 1964. Samples of surface soil taken in 1967 were cropped intensively with ryegrass in the glasshouse during 1289 days to measure K release. Two categories of non-exchangeable K were distinguished and related to

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amounts of exchangeable K. The effect on exchangeable K of air drying moist exhausted soils was measured. K added as fertiliser in 1964 increased exchangeable K in soil by only 20% but more was recovered from non-exchangeable forms. The results of the pot experiment related well to the K released from the soils in the field during nine years cropping with grass.

2.12 MATTINGLY, G. E. G. (1974) The Woburn Organic Manuring Experiment. I. Design, crop yields and nutrient balance, 1964–72. *Rothamsted Experimental Station. Report for 1973*, Part 2, 98–133.

2.13 MATTINGLY, G. E. G., CHATER, M. & POULTON, P. R. (1974) The Woburn Organic Manuring Experiment. II. Soil analyses, 1964–72, with special reference to changes in carbon and nitrogen. *Rothamsted Experimental Station. Report for 1973*, Part 2, 134–151.

The experiment described in these papers was started in 1964 to compare most of the treatments to increase soil organic matter which have previously been tested in separate experiments at Woburn. Its purpose is to evaluate, from crop yields and soil analyses, the cumulative effects of organic matter on a light, poorly-structured, soil with a long history of arable cropping. The experiment was designed to minimise the build-up of soil-borne pathogens and to avoid differential additions and removals of P, K and Mg by applying 'balancing' dressings of these nutrients in spring and autumn.

RESEARCH PAPERS

2.14 ASHWORTH, J. (1973) On measuring nitrification and recovery of aqueous ammonia applied to grassland. *Journal of Agricultural Science (Cambridge)* **81**, 145–150.

Contour diagrams, computed from analyses of soil around bands of aqueous ammonia injected under grass, show the distribution of both NH_4–N and nitrifying bacteria.

When applied at 155 kg NH_3–N/ha, either as 4·7 or 9·3 g N/m of injection slit, using knives spaced either 30 or 60 cm apart, aqueous NH_3 was recovered and nitrified more slowly in the bands 60 cm apart. Cumulative yields of grass after 32 weeks were the same (715 ± 30 g/m²) from plots injected at either spacing but growth was more even throughout the season from slits 60 cm apart.

2.15 BENZIAN, B. & SMITH, H. A. (1973) Nutrient concentrations of healthy seedlings and transplants of *Picea sitchensis* and other conifers grown in English forest nurseries. *Forestry* **46**, 55–69.

Concentrations of N, P, K, Mg, Ca, Mn were determined in whole-plant samples of healthy one-year seedlings and one-plus-one transplants of *Picea sitchensis*, *Picea abies*, *Abies grandis*, *Tsuga heterophylla*, and of seedlings only of *Pinus nigra* var. *maritima*. The samples were taken at the end of each of three consecutive growing seasons from plants grown in nursery beds on several contrasted soils in south-east England. Tops and roots were analysed separately in the last of the three years.

N, P, Ca concentrations in *Picea abies* tended to be larger than in *Picea sitchensis*, and K concentrations smaller. Concentrations of all nutrients, except Mg, were larger in tops than in roots, those of N, P, and K larger in seedlings than in transplants. With few exceptions our analytical data agree well with those published elsewhere, either for nursery-grown trees or for trees raised in culture experiments, but there is not yet sufficient evidence that these nutrient ranges have any general validity.

2.16 BOLTON, J. (1973) Total cations in the size-fractions of some British and Malayan soils and their release to H^+-resins. *Journal of the Science of Food and Agriculture* **24**, 727–738.

Total K, Na, Ca and Mg in the sand, silt and clay of six British and four Malayan soils and the proportions released to H^+-resins in 1 h, 3, 10, 23 and 43 days were measured. The clays con-

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tained and released to the resins more K and Mg than coarser fractions. The release was continuous except from the acid Malayan soils which stopped releasing K after 3 days.

More Mg was released to the resins than K, although no non-exchangeable Mg but much non-exchangeable K was released to ryegrass grown in the soils (after liming). This suggests that H^+-resins caused structural decomposition of the clay minerals which, together with the anomolous K release from acid soils, would limit their usefulness for measuring soil cations available to crops.

2.17 BOLTON, J. (1973) Sources of magnesium for sugar beet, potatoes and wheat grown on an acid sandy soil at Woburn, Bedfordshire. *Journal of Agricultural Science* (*Cambridge*) **81**, 533–535.

Epsom salt was twice as effective as dolomite and calcined magnesite in increasing crop uptake of Mg and exchangeable Mg in the topsoil. Fertiliser residues were not quickly removed by leaching.

2.18 BOLTON, J., BROWN, G., PRUDEN, G. & WILLIAMS, C. (1973) A comparison of X-ray fluorescence spectrometry and chemical methods for determining sulphur in plant material. *Journal of the Science of Food and Agriculture* **24**, 557–563.

(For summary see No. 3.4.)

2.19 BRIGGS, G. G. (1974) A simple relationship between soil adsorption of organic chemicals and their octanol/water partition coefficients. *Proceedings of the 7th British Insecticide and Fungicide Conference, Brighton, 1973*, pp. 83–86.

(For summary see p. 62 of this volume.)

2.20 BRIGGS, G. G. & WALKER, N. (1973) Microbial metabolism of 4-chloroaniline. *Soil Biology & Biochemistry* **5**, 695–697.

A yellow pigment was isolated from a culture of an aerobic Gram-negative bacterium growing on 4-chloroaniline as sole carbon source. This pigment was identified by its mass and visible spectra as 7-chloro-2-amino-3H-phenoxazin-3-one. This material can only have arisen by condensation of two molecules of 5-chloro-2-aminophenol which established the first step in the metabolism of 4-chloroaniline as a hydroxylation *ortho* to the amino group.

2.21 BROMFIELD, A. R. (1973) Uptake of sulphur and other nutrients by groundnuts (*Arachis hypogaea*) in Northern Nigeria. *Experimental Agriculture* **9**, 55–58.

The uptake of S followed a similar pattern to dry-matter production by groundnuts given enough fertiliser S to prevent S-deficiency. The fastest rate at which dry matter was produced was 140 kg/ha/day. Of the 6857 kg/ha at harvest, 3401 were in haulm, 967 in shells and 2489 in kernels. S was taken up fastest during the eighth week, when the daily average was 0·22 kg/ha; at harvest, of the 11·6 kg/ha in the plants, 5·4 was in the haulm, 0·8 in shells and 5·4 in the kernels. Of the 157 kg N/ha in the harvested crop 62% was in shells and kernels and of the 13·5 kg P/ha, 64% was in shells and kernels.

2.22 CHATER, M. & WILLIAMS, R. J. B. (1974) The chemical composition of British agricultural liming materials. *Journal of Agricultural Science* (*Cambridge*) **82**, 193–205.

Ninety-four British liming materials were examined. The contents of Ca, Mg, K, P, S, Sr, B, Fe, Mn, Zn, Cu, Co, Mo, Ni, Cd and Na in the acid-soluble fraction, and Mn, Cu, Co, Mo, Ni, Sr, Ti, Cr, Ga, Pb, Sn, V, Y, Zr and Ba in the acid-insoluble fraction were determined by chemical and spectrographic analysis. Water soluble nitrate was also determined.

Only manganese, providing on average 3 kg Mn/ha for a 10 t/ha dressing, was found in agriculturally significant quantities in the acid-soluble fraction of the limestones or shell-sands analysed. Magnesium, present only in significant amounts in the dolomitic limestones, provided on average 27 kg Mg/ha from a 10 t/ha dressing.

The acid-insoluble fraction of the limestones contained, on average, a twentieth of the concentration of Mn in the acid-soluble fraction. The concentration of K was much larger and

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depended on the amounts and nature of the insoluble fraction. The acid-insoluble fraction contained no significant amounts of other plant nutrients. The relative concentrations of Mn and K in both fractions emphasise that results based on the *total* amounts of elements in limestones could overestimate their potential value as sources of plant nutrients.

2.23 LAZARUS, W. (1973) Purification of plant extracts for ion-exchange chromatography of free amino acids. *Journal of Chromatography* **87**, 169–178.

Quantitative aspects of the ion-exchange method for purifying free amino acids from plant extracts were examined. Individual amino acids were well recovered provided excessive washing of the adsorbed amino acids with water was avoided (dilute acid could be used instead) and sufficient eluant was used. Sulphur amino acids were partly oxidised, but the loss of cystine might be acceptable and the methionine value could be corrected. Tests on extracts of Italian ryegrass (*Lolium multiflorum*) S22, Sitka spruce (*Picea sitchensis*) and Scots pine (*Pinus sylvestris* L.) gave generally satisfactory results although with 0·2 *N* sodium hydroxide eluant, some hydrolysis of glutamine was observed.

2.24 NAIR, P. K. R. & TALIBUDEEN, O. (1973) Dynamics of K and NO_3 concentrations in the root zone of winter wheat at Broadbalk using specific-ion electrodes. *Journal of Agricultural Science* (*Cambridge*) **81**, 327–337.

Procedures for measuring K^+ and NO_3^- activities in the root zones of field crops, using specific-ion electrodes, were standardised. For K, a 1·0 *M* NaCl salt bridge and KCl standards in water, for NO_3, a saturated KCl salt bridge and KNO_3 standards in water, and for both electrodes, a 1 : 0·5, soil : water ratio, and 30 s equilibration time were found satisfactory.

Recovery of added K in soil pastes by the K electrode and chemical analysis of the soil-water extract compared well, but the recovery was about 8% only. The corresponding recovery of added N was about 87 and 95% respectively.

Relative changes in the rates and magnitudes of NO_3 and K concentrations were measured with these electrodes, laterally and vertically, in the root zone, during active crop growth, from the N_2 ½(PKNaMg), N_2 PKNaMg, and N_4 PKNaMg treatments of the Broadbalk Winter Wheat experiment.

In all fertiliser treatments, at all times, the nutrient concentrations were most at 45 cm from the crop (in the uncropped area) and least within the cropped area. The differences between these extremes represent nutrient depletion by the crop, the '45 cm' measurements indicating changes in uncropped, but fertilised, areas.

Soil nitrate depletion by the crop was much more at 12·5 cm and 20 cm depths than at 5 cm. Maximum NO_3 depletion was observed during the later stages of crop growth, at 'pre-panicle emergence' and at 'grain filling'. Depletion decreased and the soil NO_3 level recovered partially as the crop reached maturity.

Periodic changes in the K concentration at each site and the corresponding K depletions were much less. Periods of K stress on the soil were few and less clearly demarcated. Soil K concentration started to recover at the 'grain filling' stage, about a month earlier than with NO_3.

Changes in NO_3 and K concentrations seem to relate more to the amounts given of each nutrient, than to the N : K ratio in each fertiliser treatment. However, changes in NO_3 and K concentrations, and also NO_3 and K depletion, occurred consecutively. This indicates an alternating periodicity in the demands of the crop for NO_3 and K respectively throughout growth.

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

Italian ryegrass, grown in pots containing potassium-deficient soil with two nitrogen levels and with or without potassium and sodium sulphates applied at equivalent rates, was analysed to assess the effects of replacing potassium by sodium on the organic constituents.

With 40 ppm of nitrogen, potassium but not sodium increased the total yield of two cuts. With 160 ppm of nitrogen, both potassium and sodium increased yields but potassium more so than sodium.

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At the lower rate of nitrogen, potassium and sodium decreased the reducing sugars, increased the sucrose but had little effect on the fructosan in the grass of the second cut. With 160 ppm of nitrogen, all the carbohydrates were increased by potassium and sodium, especially fructosan; potassium increased fructosan more than sodium. Potassium, and to a lesser extent sodium, decreased the free amino acids, ammonium- and nitrate-nitrogen and increased protein nitrogen in the grass given 160 ppm of nitrogen.

2.26 NOWAKOWSKI, T. Z., BOLTON, J. & BYERS, M. (1974) Effect of replacing potassium by sodium on growth, and on inorganic and organic composition of Italian ryegrass. *Journal of the Science of Food and Agriculture* **25**, 271–283.

Two pot experiments, one with 2^3 factorial (1969) the other with 3^3 factorial (1970) N × K × Na design, showed that yields of Italian ryegrass (*Lolium multiforum*) were increased by both potassium and sodium, when sufficient nitrogen was given, but responses to potassium were larger than to sodium. Yields were only increased by potassium fertiliser when the grass contained less than 2·0% K in the dry matter, irrespective of the Na content.

The main effect of potassium and sodium on the soluble carbohydrates was to increase the production of fructosan; again potassium was more effective than sodium.

Total N concentrations in the grass decreased with the increased production of dry matter from potassium and sodium fertilisers. Ammonium N, nitrate N and soluble organic N (expressed as the percentage of total N) were also decreased by potassium and sodium. In 1969, both potassium and sodium increased the percentages of most amino acids and decreased the percentages of asparagine and glutamine within the free amino acid pool; potassium was more effective than sodium. In 1970, sodium alone had little effect on the percentage distribution of free amino acids.

Under conditions of severe potassium deficiency sodium can substitute to some extent for potassium in its effects on yields, soluble carbohydrates and various N-fractions.

2.27 WIDDOWSON, F. V., PENNY, A. & FLINT, R. C. (1973) Results from experiments comparing aqueous and anhydrous ammonia with 'Nitro-Chalk' for grass cut for silage. *Journal of Agricultural Science* (*Cambridge*) **81**, 465–480.

In five experiments made at Rothamsted from 1966 to 1970 'Nitro-Chalk' (ammonium nitrate-calcium carbonate mixture, 21% N) was broadcast for grass cut for silage, either in a single dose in spring or divided equally for three cuts. The 'Nitro-Chalk' was used to evaluate anhydrous ammonia (82% N) in 1966, anhydrous ammonia and aqueous ammonia (approximately 26% N) in 1967, 1968 and 1969, and anhydrous ammonia, aqueous ammonia and aqueous urea (18% N) in 1970. All these fertilisers were applied to give 125, 250, 375 and 500 kg N/ha, except in 1968 when 250, 375, 500 and 625 kg N/ha were given.

Anhydrous ammonia gave smaller yields (of dry matter) than the other N fertilisers except in 1968, a wet year, when it was at least as good as 'Nitro-Chalk', but slightly less good than aqueous ammonia. Yields were larger with autumn- than with spring-injected aqueous ammonia and larger with either, than with equivalent single doses of 'Nitro-Chalk'. Yields with aqueous ammonia were also larger than with 'Nitro-Chalk' divided equally for three cuts when more than 375 kg N/ha was tested, but smaller with less. Aqueous urea was as good as a single dose of 'Nitro-Chalk' but less good than divided 'Nitro-Chalk' in 1970, the only year it was tested. 'Nitro-Chalk' divided equally for three cuts gave larger yields than when a single dose of up to 375 kg N/ha was given, but with more N than this a single dose was better.

Apparent recovery of N was least from anhydrous ammonia and differed little between autumn and spring injection in 1968, the only year when a valid comparison was possible. Apparent recoveries of N from autumn and from spring-injected aqueous ammonia and from 'Nitro-Chalk' broadcast in a single dose differed little, nor did the proportion of the N recovered at each cut. Recovery from 'Nitro-Chalk' broadcast in three equal amounts was more uniform, but little larger.

Judged by yield, no more than 375 kg N/ha was justified; grass given this amount of N either as aqueous ammonia or as 'Nitro-Chalk' removed approximately 29 kg N, 3 kg of P (7 kg P_2O_5), 26 kg of K (31 kg K_2O) and 2 kg of Mg (3 kg MgO)/t dry matter produced.

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2.28 WIDDOWSON, F. V., PENNY, A. & FLINT, R. C. (1974) Results from experiments measuring the effects of large amounts of fertiliser and of farmyard manure on main-crop potatoes grown in sandy soil at Woburn, Bedfordshire. *Journal of Agricultural Science (Cambridge)* **82**, 117–127.

The largest yields of potatoes in the Woburn Reference experiment were obtained by giving both farmyard manure (FYM) and fertilisers, rather than fertilisers alone; an explanation was sought in experiments made on the coarse sandy loam there from 1968–71. Each year, single and double amounts of NPK fertiliser (supplying 250 or 500 kg N/ha plus P and K) were incorportated, either deeply or shallowly, into the seedbed. From 1969, FYM also was tested at rates giving the same amounts of N, similar amounts of K, but more P than the fertilisers; it was tested both alone and with fertilisers.

FYM was less effective than fertiliser when given alone. The combination of FYM and fertiliser gave a larger yield than the single amount of fertiliser and a larger yield than the double amount of fertiliser incorporated shallowly, but a smaller yield than the double amount of fertiliser incorporated deeply, which gave the largest yield each year.

The NPK contents of the potato tubers were used to construct nutrient balance sheets; large residues of N, P and K remained in the soil after harvest. Winter wheat was grown to value these in 1971 and 1972. Fertiliser residues increased only straw yields, but FYM residues increased yields of both grain and straw. Both kinds of residues were less effective than freshly applied N, so most of the N leached during winter.

The yield of saleable tubers was increased, not decreased, by the double amount of fertiliser.

Pedology Department

GENERAL PAPERS

3.1 BLOOMFIELD, C. (1972) Some chemical properties of hydromorphic soils. In Pseudogley and Gley. *Transactions of Commissions V & VI of the International Sociiety of Soil Science, Stuttgart, 1971.* Ed. E. Schlichting & U. Schwertmann, pp. 7–16.

3.2 BLOOMFIELD, C. & COULTER, J. K. (1973) Genesis and management of acid sulphate soils. *Advances in Agronomy* **25**, 265–326.

RESEARCH PAPERS

3.3 BLOOMFIELD, C. & KELSO, W. I. (1973) The mobilisation and fixation of molybdenum, vanadium and uranium by decomposing plant matter. *Journal of Soil Science* **24**, 368–379.

Mo, V and U are mobilised as anions by aerobically decomposing plant matter; the behaviour of the dissolved metals differs in several respects from what would be expected in inorganic systems. When dialysed through cellophane, between pH 1 and 4 the mobilised Mo is fixed by colloidal organic decomposition products, with maximum retention at pH 1·5; V is retained between pH 1·5 and 7·0, with a maximum at pH 3. Per unit of organic C, the specific fixation of Mo and V by soil organic matter was considerably less, and persisted over wider pH ranges—1·5–6·5 and 1·0–9·0 respectively. The fixation of U by both forms of humified organic matter increased sharply to a maximum around pH 4–5, and thereafter decreased slightly up to pH 8.

The anionic forms of the three elements persisted when MoO_4^{2-}, VO_3^- and UO_3^- were incubated with anaerobically decomposing plant matter; under these conditions V(V) was probably reduced to V(IV), and it seems that an anionic V(IV) complex was formed.

Although the molecular size of the colloidal decomposition products of lucerne was somewhat less than that of organic matter extracted from Rothamsted topsoil, acid hydrolysates of the two humic acids contained the same 23 amino acids, in much the same relative proportions.

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3.4 BOLTON, J., BROWN, G., PRUDEN, G. & WILLIAMS, C. (1973) A comparison of X-ray fluorescence spectrometry and chemical methods for determining sulphur in plant material. *Journal of the Science of Food and Agriculture* **24**, 557–563.

A rapid method for determining total S in plants by X-ray fluorescence spectrometric analysis of ground pelletised plant material is compared with chemical methods using titrimetric, flame photometric and turbidimetric methods of sulphate determination. Errors in the chemical methods were caused by incomplete oxidation of organic sulphur and by non-reproducibility of the turbidimetric determination of sulphate. A method incorporating oxidation with HNO_3 and $Mg(NO_3)_2$, followed by reduction of the resulting sulphate to H_2S, which was titrated with mercuric acetate gave recoveries accurate to a mean of 1% when determining the sulphur content of sulphur compounds.

Taking the results for plant materials determined by the titrimetric method as standard, XRF gave sulphur values with a mean difference of 4%; the flame photometric determination of sulphate after $HNO_3 + Mg(NO_3)_2$ oxidation gave results with a mean difference of 12%. The effect of absorption of S radiation by silicon is noted.

3.5 BROWN, G. & NEWMAN, A. C. D. (1973) The reactions of soluble aluminium with montmorillonite. *Journal of Soil Science* **24**, 339–354.

The amount of aluminium sorbed from a basic aluminium chloride solution depends on the ratio of OH to Al in the original solution. Except when OH/Al = 0, only part of the sorbed Al is exchanged by dilute solutions of barium or calcium chloride and the exchange capacity of the clay decreases in proportion to the amount of aluminium retained by the clay. Al-bentonite appears to contain a mixture of Al^{3+} and a basic cation in which OH/Al is 2·5. Neutralising Al-bentonite with calcium acetate of pH 7·2 restores only part of the exchange capacity, and some charged interlayer aluminium is thought to remain in the clay at this pH. It therefore seems possible that charged interlayer aluminium may be found even in soils with a neutral reaction.

3.6 CATT, J. A. & WEIR, A. H. (1973) The sediments. Contribution to: The Late Pliocene Marine Formation at St. Erth, Cornwall. *Philosophical Transactions of the Royal Society, B* **266**, 12–18.

New excavations were made in the long-abandoned sand and clay pits at St. Erth, Cornwall, from which rich collections of marine mollusca and foraminifera have come in the past. The sediments and stratigraphy revealed are described, and the results of detailed studies of the fossils (mollusca, foraminifera, ostracoda and plants) in the marine clay are given. The sand member is well sorted, and in places contains two fine-sand populations, one of beach and the other of dune origin. The clay member was probably deposited not far below low-water mark in a sea whose temperature was higher than that of Cornwall today, at the time when the final Boytonian beds of the Pliocene Coralline Crag were being deposited in East Anglia, and the Pliocene *marnes à Nassa* were being deposited at Bosq d'Aubigny in Normandy. The sea level seems to have been lowered by about 45 m to its present level since the marine clay was deposited. The possibility of crustal movement in Cornwall is considered.

3.7 FINDLAY, D. C., CATT, J. A., ORMEROD, E. C., WEIR, A. H. & DAVIES, H. (1973) A Sequence of Soils in the Middle Awash Valley, Ethiopia. *African Soils* **18**, 1–18.

A sequence of soils typical of the Middle Awash basin (Ethiopia) and derived mainly from glassy per-alkaline pumice (pantellerite) is described. The sequence is one of increasing clay content, salinity and alkalinity, dependent mainly upon rapid weathering of volcanic glass in a semi-arid climate. The soils have large cation exchange capacities, but do not swell and shrink markedly; possible reasons for this are discussed.

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3.8 GREENE-KELLY, R. (1973) The preparation of clay soils for determination of structure. *Journal of Soil Science* **24**, 277–283.

Most methods of determining soil structure require the soil to be prepared free of water, yet retaining its original character. Freeze-drying and critical point-drying were examined and it was concluded that these methods are not satisfactory in every instance. The soil fabric can be preserved by slowly exchanging water with an organic solvent such as methanol or dioxan, and the consequent hardening of the fabric may be increased by exchange with some water-immiscible solvents, for example, diethyl ether. However, some shrinkage must be tolerated if liquid is to be removed from the fabric. The best method of preserving the soil fabric is infiltration by liquid carbon dioxide and subsequent evaporation above the critical temperature; despite some shrinkage, the fabric seems to be unchanged.

3.9 KALEMBASA, S. J. & JENKINSON, D. S. (1973) A comparative study of titrimetric and gravimetric methods for the determination of organic carbon in soil. *Journal of the Science of Food and Agriculture* **24**, 1085–1090.

Two gravimetric procedures for determining carbon in soil, one a dry combustion method and the other a wet oxidation method, were compared with seven variants of the titrimetric method, all based on determination of the dichromate consumed when soil is heated with dichromate and acid. The coefficients of variation of the methods were, as percentages: dry combustion, 0·76; wet combustion, 1·1; Tinsley I, 1·3; Tinsley II, 1·8; Tinsley III, 0·8; Anne, 1·3; Mebius, 1·8; Walkley and Black, 1·6 and Tyurin, 8·5. Taking the dry combustion method as standard, the % recovery of organic carbon from 22 soils was 99 for wet combustion, 95 for Tinsley I, 95 for Tinsley II, 97 for Tinsley III, 93 for Anne, 95 for Mebius, 77 for Walkley and Black and 93 for the Tyurin method. A variant of the Tinsley method (Tinsley III) is proposed as a quick procedure when the accuracy of dry combustion is not essential.

3.10 LE RICHE, H. H. (1973) The distribution of minor elements among the components of a soil developed on loess. *Geoderma* **9**, 43–57.

This previously-described buried soil, developed in uniform parent material, was used to study the relative movements of elements and other soil components down the profile. Samples from all horizons were treated with hydrogen peroxide and ammonium oxalate, under ultra-violet light, to remove organic matter and sesquioxides, and the residues were subdivided into six particle size fractions.

Downward movement of clay ($<0{\cdot}5\ \mu$m) was accompanied by movement of extractable Al_2O_3 and Fe_2O_3, thus identifying these as part of the mobile fraction. The less close relationship of extractable Fe_2O_3 to the clay suggested that it also occurred partly in coarser aggregates. The proportions of minor elements extracted varied from $<1\%$ for Sr to nearly complete extraction of Co, Cu and Mo in some horizons. The extractable fractions of most minor elements throughout the profile behaved more like Fe_2O_3 than Al_2O_3. In the extraction residues nearly all elements were enriched in the clay fractions relative to the coarser fractions, the increase being greatest for V and Fe.

3.11 LE RICHE, H. H. (1973) The distribution of boron in a soil developed in loess in relation to the weathering of glauconite. *Geoderma* **9**, 143–147.

The distribution of boron between particle size fractions was studied after removing sesquioxides. Most of the relatively large amount of boron in the glauconite contained in this soil remained in the clay minerals when the glauconite broke down. The soil lost a larger amount of boron from other minerals than from glauconite.

3.12 (TRAFFORD, B. D.), BLOOMFIELD, C., KELSO, W. I. & PRUDEN, G. (1973) Ochre formation in field drains in pyritic soils. *Journal of Soil Science* **24**, 453–460.

Two distinct forms of ochre are known to occur in field drains. One form, which is most common in wet peaty areas, is caused by the growth of filamentous iron bacteria. The second form is associated with *Thiobacillus ferrooxidans*, and occurs where the soil contains pyrite.

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Contrary to previous reports, liming decreases the rate at which pyrite is oxidised in soil and, by decreasing the amount of iron entering the drains in a given period, should significantly increase the active life of the drainage system. Regular liming is probably preferable to a single large initial dressing.

3.13 WILLIAMS, C. & (THORNTON, I.) (1973) The use of soil extractants to estimate plant-available molybdenum and selenium in potentially toxic soils. *Plant & Soil* **39**, 149–159.

The uptake of Mo and Se by plants growing on soils with larger than normal concentrations of these elements cannot be predicted from the soil contents alone.

The results of the chemical extraction of Mo and Se from soils in the laboratory are compared with plant uptake of Mo and Se from the same soils in greenhouse experiments. The uptake of Mo and Se is correlated with the EDTA-extractable Mo and Se in the soil, and the uptake of Mo with the ammonium acetate-extractable Mo.

The role of pH, organic matter, and other soil properties are discussed with regard to Mo and Se availability and to the interpretation of results obtained by laboratory extractions.

Soil Microbiology Department

GENERAL PAPERS

4.1 MOSSE, B. (1973) Advances in the study of vesicular-arbuscular mycorrhiza. *Annual Review of Phytopathology* **11**, 171–196.

4.2 SKINNER, F. A. (1974) (Ed.) IBP World Catalogue of Rhizobium Collections. Compiled by O. N. Allen and Eva Hamatová. London: International Biological Programme.

4.3 WALKER, N. (1973) Microbial degradation of pesticides and herbicides with special reference to phenylcarbamate and phenylurea herbicides. *Atti del XVI Congresso Nazionale di Microbiologia* (*Societa Italiana di Microbiologia*) **1**, 255–261.

RESEARCH PAPERS

4.4 BRIGGS, G. G. & WALKER, N. (1973) Microbial metabolism of 4-chloroaniline. *Soil Biology & Biochemistry* **5**, 695–697.

A soil bacterium able to grow with 4-chloroaniline as its sole carbon source has been isolated from linuron-treated soil. By adding successive doses of 4-chloroaniline to a liquid culture of the organism a yellow pigment was formed. By mass spectrum analysis the substance was identified as 7-chloro-2-amino-3H-phenoxazin-3-one which probably arose from the reaction of two molecules of 5-chloro-2-aminophenol. Hence the first step in the microbial metabolism of 4-halogenoanilines is established as hydroxylation *ortho* to the amino group.

4.5 HAYMAN, D. S. (1974) Plant growth responses to vesicular-arbuscular mycorrhiza. VI. Effect of light and temperature. *New Phytologist* **73**, 71–80.

In P-deficient soil mycorrhizal infection in onion roots was strongly arbuscular and greatly stimulated host growth at high light intensity at 23° or a 14–23°C diurnal cycle, but had little effect in low light at 14°C. At 18°C infection was much sparser in a short daylength than in long daylengths. Stimulation of host growth by the infection increased with increasing light intensity and daylength. The addition of soluble phosphate stimulated growth to the same extent as mycorrhizal inoculation in the highest light conditions but phosphate stimulated growth more than did mycorrhiza under intermediate light conditions. The roots of plants grown in most light contained most soluble carbohydrate, the amount being similar in the presence or absence of mycorrhiza, and including much glucose, fructose and sucrose.

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4.6 MOSSE, B., HAYMAN, D. S. & ARNOLD, D. J. (1973) Plant growth responses to vesicular-arbuscular mycorrhiza. V. Phosphate uptake by three plant species from P-deficient soils labelled with ^{32}P. *New Phytologist* **72**, 809–815.

In two very P-deficient ^{32}P-labelled soils the specific activity of phosphorus taken up by mycorrhizal and non-mycorrhizal *Melinis minutiflora* was very similar, indicating that even where little soluble phosphate is present mycorrhizal plants used the same source of phosphate as non-mycorrhizal. In two other very P-deficient ^{32}P-labelled soils non-mycorrhizal *Paspalum notatum* and *Centrosema pubescens* contained no ^{32}P activity, whereas mycorrhizal plants did and grew much better. It is suggested that non-mycorrhizal roots of some plant species do not take up phosphate present at extremely low concentrations in the soil solution, but that mycorrhizal roots or fungal hyphae do.

4.7 PEARSON, V., BROWN, M. E. & HORNBY, D. (1973) Some observations on microbial populations and nitrogen in soils infested with the take-all fungus. *Pesticide Science* **4**, 397–398.

Some possible causes of 'take-all decline', the decrease in the severity of attack by *Gaeumannomyces graminis* on cereals after several year's consecutive culture, are discussed. The possible relationships between the NO_3^-–N : NH_4^+–N ratio in the rhizosphere, populations of rhizosphere bacteria and the incidence of take-all are considered.

4.8 (SORIANO, S.) & WALKER, N. (1973) The nitrifying bacteria in soils from Rothamsted classical fields and elsewhere. *Journal of Applied Bacteriology* **36**, 523–529.

Ammonia-oxidizing autotrophic nitrifying bacteria in soil samples from three classical Rothamsted fields and elsewhere were counted by a modified 2-layered silica gel plating method. Counts ranged from 0–18000/g dry soil, the maximum number being found in the Broadbalk farmyard manure plot. *Nitrosomonas europaea* was isolated in pure culture and detected only in soils treated with dung or other organic fertiliser. *Nitrosocystis coccoides* and *Nitrosospira* spp. were found in other soils. *Nitrobacter* spp. were present in many soils and of the 18 pure cultures isolated there seemed to be three, or possibly four, different colony types.

4.9 (SPOKES, J. R.) & WALKER, N. (1974) Chlorophenol and chlorobenzoic acid co-metabolism by different genera of soil bacteria. *Archiv für Mikrobiologie* **96**, 125–134.

Four *Pseudomonas* strains, an *Achromobacter* sp., three *Nocardia* strains, *Mycobacterium coeliacum* and a *Bacillus* sp., grown on either phenol or benzoic acid as sole carbon source were tested for co-oxidation or mono-chlorophenols and mono-chlorobenzoates respectively. The *Pseudomonas* spp., *Nocardia* spp., *M. coeliacum* and the *Bacillus* sp. showed O_2-uptakes in the presence of 2-, 3- or 4-chlorophenol and oxidised them to either 3- or 4-chlorocatechol.

Benzoate-grown cells of the three *Nocardia* spp. and three of the pseudomonads absorbed O_2 only in the presence of 3-chlorobenzoate, 4-chlorocatechol being identified as the oxidation product in two cases. Benzoate-grown *Bacillus* cells gave O_2-uptakes with either 3- or 4-chlorobenzoate and the former was oxidised to 5-chloro-2, 3-dihydroxybenzoic acid via 5-chlorosalicylic acid, thus representing a novel metabolic pathway.

4.10 WALKER, N. (1973) Metabolism of chlorophenols by *Rhodotorula glutinis*. *Soil Biology and Biochemistry* **5**, 525–530.

A phenol-utilising strain of *Rhodotorula glutinis* was isolated from Rothamsted soil. Washed phenol-grown *R. glutinis* cells oxidised 3- and 4-chlorophenols to 4-chlorocatechol, and 4-bromophenol presumably to 4-bromocatechol. Phenol-grown cells consumed O_2 in the presence of 2-, 3- or 4-chlorophenol, 4-bromophenol, 2,4-dichloro- and 2,4-dibromophenol. Benzoate-grown cells showed O_2-uptakes in the presence of 2-, 3- or 4-chlorobenzoate but the formation of catechol compounds was not definitely established.

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Botany Department

General Papers

5.1 Welbank, P. J. (1974) Research on root growth at Rothamsted. In: *Soil physical conditions and crop production. Ministry of Agriculture, Fisheries and Food. Technical Bulletin* No. 29. London: HMSO, pp. 449–460.

5.2 Welbank, P. J. (1974) Root growth of different species and varieties of cereals. *Journal of the Science of Food and Agriculture* **25**, 231–232.

Papers in Rothamsted Report, Part 2

5.3 Thorne, G. N. (1974) Physiology of grain yield of wheat and barley. *Rothamsted Experimental Station. Report for 1973*, Part 2, 5–25.

5.4 Welbank, P. J., (Gibb, M. J.), Taylor, P. J. & Williams, E. D. (1974) Root growth of cereal crops. *Rothamsted Experimental Station. Report for 1973*, Part 2, 26–66.

The soil coring method used at Rothamsted to sample roots of field crops is described in detail, together with methods for cleaning and measuring roots.

Six experiments on cereal crops grown on sandy loam studied the effects on root growth of nitrogen, phosphorus and potassium fertilisers and shading and compared root growth of winter wheat, spring wheat, oats and barley and different varieties of winter wheat.

When sampling was continued to crop ripeness, maximum root dry weights were found about ear emergence. As much as 80% of roots recovered at that stage were in the top 15 cm of soil. Nitrogen fertiliser produced smaller root systems in the early spring, affecting particularly younger and more actively growing parts of the root system and tending to produce roots which were shorter relative to their dry weight. Later, although it produced absolutely larger root systems it increased root growth much less than shoot growth and depressed the size of the root system relative to the plant as a whole. Phosphorus and potassium fertiliser applied to barley produced small increases in growth of the plants as a whole, but did not generally affect roots independently of the rest of the plant.

Shade decreasing the incident light by 20 or 50% was applied to barley for one, two or four week periods between the four-leaf stage and the early grain growth period. Shading decreased root growth somewhat more than proportionally to the degree of shade, and shoot growth somewhat less, when it was applied while the roots were growing most actively, but it did not have as much effect on roots when their growth slowed about the time of flowering. Roots deeper than 15 cm were affected more than roots near the surface. The results suggest that shortage of carbohydrate caused by reduced light intensity affects root growth more than shoot growth; stimulation of shoot growth by nitrogen fertiliser may similarly restrict carbohydrate supply to roots and hence their growth.

Winter wheat had 5–6% of its maximum (presumed) root dry weight by the end of March in one experiment and as much as 30–40% in others. It had a greater dry weight and length of roots during the early spring than spring-sown wheat, oats or barley, but by ear emergence oats had a greater weight and barley a greater length. As early as five weeks after sowing, spring-sown cereals had smaller fractions of their total weight represented by roots than winter wheat.

Different winter wheat varieties, including Cappelle-Desprez, Maris Nimrod, Maris Ranger and new semi-dwarf varieties, differed little in dry weights or length of their roots. However, some varieties had less roots than others at depths greater than 30 cm in spring.

Compared with other methods available for investigating root systems, the sampling methods used permit measurement of weight, length and other physical attributes of roots and their chemical composition if required. Other methods can be used to detect living roots or to study the distribution of root activity.

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5.5 WILLIAMS, E. D. (1974) Changes in yield and botanical composition caused by the new liming scheme on Park Grass. *Rothamsted Experimental Station. Report for 1973*, Part 2, 67–73.

RESEARCH PAPERS

5.6 BIRD, I. F., CORNELIUS, M. J., KEYS, A. J. & WHITTINGHAM, C. P. (1973) The intracellular site of sucrose synthesis in leaves. *Phytochemistry* **13**, 59–64.

Improved conditions for extraction and assay increased by 20-fold rates of sucrose synthesis from UDP glucose plus fructose 6-phosphate catalysed by leaf extracts. Rates of 17·9, 25·0, 9·2 and 27·7 μmol $h^{-1}g^{-1}$ fresh weight respectively were obtained with extracts of pea shoots, spinach, wheat and bean leaves. Preparations of chloroplasts, in which half the plastids were intact, contained less than 4% of the total UDP glucose-fructosephosphate glucosyltransferase, more than 30% of the ribulose diphosphate carboxylase, and more than 40% of the total chlorophyll of the leaf. Although some UDP glucose-fructosephosphate glucosyl-transferase was associated with particles smaller than chloroplasts, at least 85% of the enzyme was not precipitated at 38 000 g. UDP glucose pyrophosphorylase, also thought to be essential for sucrose synthesis, was distributed between cell fractions in a similar manner to UDP glucose-fructosephosphate glucosyltransferase. It is concluded that sucrose synthesis in pea shoots and spinach leaves occurs mainly in the cytoplasm.

5.7 (FORD, M. A.) & THORNE, G. N. (1974) Effects of atmospheric humidity on plant growth. *Annals of Botany* **38**, 441–452.

Increasing the atmospheric humidity in growth rooms increased growth of sugar beet in four experiments, of kale in two experiments and of wheat in three experiments. Growth of wheat was unaffected in another three experiments. The effects were variable and did not occur at all stages of growth. In general, decreasing the vapour pressure deficit by 5 mb (e.g. increasing the relative humidity from 70–90% at 20°C) increased dry weight by 20–30% and sometimes by considerably more.

Sugar beet and kale were more sensitive than wheat. Relatively, dry weight of tops was affected more than root weight and leaf area was affected more than total dry weight, so net assimilation rate decreased with increase in humidity. Water loss per plant depended on the vapour pressure deficit of the air, leaf area and species; it was only slightly affected by wind speed. Water loss per unit leaf area was less for wheat than for the other species and less for large than small plants.

5.8 LAWLOR, D. W. & MILFORD, G. F. J. (1973) The effect of sodium on growth of water-stressed sugar beet. *Annals of Botany* **37**, 597–604.

Sugar beet grown in solution culture, with or without a supplement of 16 meq. $litre^{-1}$ of sodium, were subjected to water stress with polyethylene glycol solutions of −0·4, −3, and −8 bar osmotic potential. With the −0·4 bar solution leaf water potential was between −6 and −8 bar and leaf relative water content about 90%. Decreasing the solution osmotic potential to −8 bar decreased leaf water potential to about −15 bar and relative water content to 75%; the leaves stopped expanding and transpiration and carbon dioxide uptake were decreased by 80 and 50% respectively. Net assimilation rates were only slightly decreased because leaf growth was decreased more than carbon dioxide assimilation. Relative growth rates of the plants were decreased by 8% at −3 bar and by 15% at −8 bar.

Sodium absorbed by the plant accumulated mainly in the leaves and petioles; it increased the water content of the leaves and storage root and the plant fresh weight. Sodium decreased the leaf osmotic potential, slightly increased leaf water potential, and significantly increased turgor. It had no effect on carbon dioxide uptake, transpiration, net assimilation rate, or relative growth rate. Sodium increased the rate at which the leaf area grew and it is concluded that it did so by altering the leaf water balance.

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5.9 (LUPTON, F. G. H., ELLIS, F. B.), WELBANK, P. J., (BARNES, B. T., HOWSE, K. R., OLIVER, R. H.) & TAYLOR, P. J. (1974) Root and shoot growth of semi-dwarf and taller winter wheats. *Annals of Applied Biology* **77**, 129–144.

Experiments in three seasons compared shoot growth of different varieties and the distribution of their roots with depth, estimated by injecting ^{86}Rb into stem bases and measuring the radioactivity in soil cores containing roots, and by extracting the roots from soil cores and measuring their lengths and dry weights; and also studied the relative ability of roots to absorb phosphate from different depths, estimated from the recovery in the shoots of ^{32}P injected into the soil at different depths. Relative growth rates of shoots followed a sigmoid time-course, but those of roots changed little between germination and anthesis. Different varieties differed little in shoot or total root growth; but there was evidence that below 25 cm deep roots of the semi-dwarf varieties were more extensive and absorbed more phosphate than those of the taller varieties.

5.10 MILFORD, G. F. J. (1973) The growth and development of the storage root of sugar beet. *Annals of Applied Biology* **75**, 427–438.

A study was made of the growth of the storage root of sugar beet as a sugar-accumulating organ. The storage root grew by simultaneous cell multiplication and expansion from a series of peripheral secondary meristems laid down during the early stages of development. The weight of water and of non-sugar dry matter per cell increased in proportion to the increase in cell volume. The amount of sugar per cell was proportional to cell volume only during the initial stage of cell expansion up to volumes of about 15×10^{-8} cm^3; thereafter it was less proportional. Thus, average cell size is a major determinant of the sugar concentration of the storage root. The implications of this are discussed.

5.11 MILFORD, G. F. J. & THORNE, G. N. (1973) The effect of light and temperature late in the season on the growth of sugar beet. *Annals of Applied Biology* **75**, 419–425.

Sugar-beet plants were subjected to all combinations of two day temperatures (12·5 and 18·5°C), two night temperatures (8·0 and 14·0°C) and two light intensities (275 and 550 J cm^{-2} of visible radiation in a 12 hour day) during the last month of their growth. Cold day or night temperatures resulted in the plants having slightly smaller leaf areas, final dry weights and amounts of sugar in their roots than plants grown in warm temperatures. Plants grown in the cold also contained less water, particularly those given cold nights, so that they had smaller fresh weights and a greater concentration of sugar in the fresh, but not in the dry roots, than plants grown in warm conditions. Halving the light intensity had little effect on leaf area but decreased the net assimilation rate. The final dry weight of the shoot was not affected by changing the light intensity, but the dry weights of the roots of plants grown in dim light were 20% smaller than in plants grown in bright light and they contained correspondingly less sugar. There was no effect of varying the light intensity on the concentrations of sugar in the fresh or dry roots. There was no evidence that cold night temperatures, either alone or in conjunction with bright conditions during the day, induced the storage root to accumulate sugar faster relative to non-sugar dry matter, i.e. to 'ripen'.

5.12 WHEELER, A. W. (1973) Longitudinal distribution of growth substances in leaves of wheat (*Triticum aestivum* L.). *Planta* **112**, 129–135.

The basal fifth of the lamina, containing most of the gibberellin of young leaves, was the only part of the lamina that elongated. When the base of the lamina stopped elongating the gibberellin apparently moved up the lamina, but the leaf sheath still contained some gibberellin and continued to elongate. Old, fully elongated, leaves contained most auxin and tryptophan in the apical fifth of the lamina that was dying: the young leaves contained insignificant amounts of auxin. Leaves contained two cytokinins; generally most cytokinin activity occurred in the apical fifth of leaves. Cytokinin activity was also detected in guttation drops and in ethanolic washings from leaf tips.

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5.13 WILLIAMS, E. D. (1973) Variation in growth of seedlings and clones of *Agropyron repens* (L.) Beauv. *Weed Research* **13**, 24–41.

The growth of *Agropyron repens* seedlings, or of clones derived from them, raised from seeds collected from different areas was compared; the growth of seedlings raised from seeds from single spikes and from seeds of a cross of two clones was also compared.

The number and length of shoots and the amount of rhizome produced differed between seedlings from different areas. Seedlings with a large weight of rhizomes often had a small weight of shoots. Many of the differences found between seedlings from different areas were confirmed by comparing clones established from some of them. Comparisons of both seedlings and clones showed that the percentage of shoots that developed spikes differed between genotypes; clones with the least weight of rhizome tended to have most weight of spikes. Large variations also occurred between clones established from seedlings from a given area, particularly in the way their dry weight was partitioned between primary and secondary shoots and in the time the spikes emerged.

The amount of rhizome per seedling varied greatly between seedlings from seeds from single spikes and from seeds from a cross of two clones. There was some evidence of a negative correlation between per cent shoot and per cent rhizome dry weight with seedlings from single spikes and between number of shoots and number of rhizomes per seedling with seedlings from a cross of two clones.

5.14 WILLIAMS, E. D. (1973) Seed germination of *Agrostis gigantea*, Roth. *Weed Research* **13**, 310–324.

To assess the role of seed production and seedling behaviour in the biology of the perennial grass weed *Agrostis gigantea* Roth, seed germination and seedling emergence of the species were investigated in the glasshouse and in the laboratory. These studies showed that the species may produce a large number of seeds; panicles collected from a cereal field in 1971 and 1972 contained about a thousand viable seeds in both years. Mature seeds of the species are mostly non-dormant and germinate readily on moist soil surfaces. Freshly-harvested seeds require light and alternating temperatures for germination, but older seeds can germinate in constant temperature in the dark. Covering seeds with 0·6 cm soil halved the percentage emergence and few seedlings emerged from seeds sown deeper than 3·8 cm, but many seeds survived under enforced dormancy. *A. gigantea* seeds may also persist long in frequently cultivated shallow soil. The species flowers late but its seeds become viable quickly—in 1969 a third of the number that were finally viable became so within a week of flowering.

5.15 WILLIAMS, E. D. (1973) A comparison of the growth, and competition with wheat, of seedlings and plants from rhizomes of *Agropyron repens* (L.) Beauv. and *Agrostis gigantea* Roth. *Weed Research* **13**, 422–429.

Seedlings and plants derived from single-node rhizome fragments of *Agropyron repens* and *Agrostis gigantea* were grown in an unheated glass-house, separately or together with wheat (cv. Kolibri), in sandy loam soil in well-spaced pots, adequately watered and moderately fertilised. Samples of crop and weeds were taken for growth analysis in mid-May, late June and early August (when the wheat was ripe).

On average, wheat decreased the weight of weed shoots by 84% and of rhizomes by 77%, but the weeds decreased the weight of wheat shoots by only 7% and of grain by 13%. Without wheat, seedlings of both weed species had, by late June, grown as much as plants from rhizomes, but with wheat, the weed seedlings were throughout most of the experiment more susceptible to competition than were plants from rhizomes. There was no simple relationship between the final dry weights of the weeds and the amount they decreased wheat yield: although *Agropyron* seedlings in competition with wheat were much lighter than *Agrostis* from rhizomes, they decreased grain yield of wheat as much, suggesting that they competed more intensely for a limiting factor, possibly nitrogen.

It is concluded that the faster initial growth rate of wheat seedlings relative to the weeds from rhizomes and a larger initial seed reserve relative to the weed seedlings enabled the wheat to dominate the weeds.

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Biochemistry Department

General Papers

6.1 Fowden, L. (1973) Amino acids. In: *Phytochemistry*. Ed. L. P. Miller. New York: Van Nostrand-Reinhold, **2**, pp. 1–29.

6.2 Fowden, L. (1973) The non-protein amino acids of plants: concepts of biosynthetic control, In: *Biosynthesis and its control in plants*. Ed. B. V. Milborrow. London: Academic Press, pp. 323–339.

6.3 Fowden, L. (1973) Phytochemistry: retrospect and prospect. In: *Phytochemistry*. Ed. L. P. Miller. New York: Van Nostrand-Reinhold, **3**, pp. 400–405.

6.4 Lea, P. J. & (Norris, R. D.) (1972) tRNA and aminoacyl-tRNA synthetases from plants. *Phytochemistry* **11**, 2897–2920.

6.5 Miflin, B. J. (1973) Amino acid biosynthesis and its control in plants. In: *Biosynthesis and its control in plants*. Ed. B. V. Milborrow. London: Academic Press, pp. 49–68.

6.6 Pirie, N. W. (1973) Production and use of unconventional sources of food. In: *Man, food and nutrition*. Ed. M. Recheigl, US Dept. State Agency for International Development, pp. 189–202.

6.7 Pirie, N. W. (1973) On being the right size. *Annual Review of Microbiology* **27**, 119–132.

Research Papers

6.8 Arkcoll, D. B. (1973) The preservation and storage of leaf protein preparations. *Journal of the Science of Food and Agriculture* **24**, 437–445.

Moist leaf protein is most readily preserved for a few months by adding 1% acetic acid. When dried leaf protein is stored there is oxidation of the lipid fraction which decreases the carotenoid and tocopherol contents, and affects the nutritional value and palatability of the protein. Oxidation is especially rapid when products are stored in the light because of the catalytic effect of chlorophyll. The preparations contain 0·8–1·7 mg/g of β-carotene that oxidises fast giving some protection to other lipids. Using carotene oxidation as an index, satisfactory storage is best achieved by processing extracts rapidly to avoid the destruction of natural antioxidants and the formation of lipoperoxides in the juice; dried products will then keep well at room temperature packed tightly in bags impermeable to light and oxygen.

6.9 Arkcoll, D. B. & Davys, M. N. G. (1973) Mechanical fractionation as an aid to crop drying. *1st International Green Crop Drying Congress, Oxford, 8–13 April 1972*, pp. 354–360.

Mechanical fractionation could considerably increase the profitability and scale of the crop-drying industry as well as producing a valuable source of protein for monogastric animals in Britain. The lower moisture content of extracted material offered to the drier increases throughput, eases control and allows crops of higher moisture, protein and digestibility to be grown and processed. The levels of crop moisture and protein at which extraction becomes worthwhile, the degree of extraction and the feeding of either whole juice or separated protein curd, depend on the relative value of the different products, the cost of fuel, storage and disposal of the 'whey'.

6.10 Arkcoll, D. B. & Holden, M. (1973) Changes in chloroplast pigments during the preparation of leaf protein. *Journal of the Science of Food and Agriculture* **24**, 1217–1227.

The nature and extent of the changes in the carotenoids and chlorophylls were determined at each stage of leaf protein (LP) preparation. Loss of carotenoids during pulping and pressing of

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the leaves is mainly enzymic and can be minimised by adding alkali and processing quickly. Carotenoids were more stable in the juice than in the fibre. When the protein was coagulated by heating the juice little carotene was destroyed but total xanthophyll decreased mostly due to violaxanthin being partly isomerised. With leaves rich in chlorophyllase, coagulating at 80°C led to the conversion of chlorophylls to chlorophyllides. This reaction, and others that may be deleterious to the quality of the protein, did not occur at 100°C suggesting a higher temperature of coagulation may be preferable. Washing with acid caused a marked colour change of LPs because of the conversion of chlorophylls to pheophytins and chlorophyllides to pheophorbides; xanthophyll decreased slightly but carotene was unaffected. No pigment changes occurred on freeze-drying. During storage with air present carotene was less stable than xanthophyll; carotenoids were lost faster from acid-washed LPs than from unwashed preparations.

6.11 HILL, J. M. (1973) The changes with age in the distribution of copper and some copper-containing oxidases in red clover (*Trifolium pratense* L. cv. Dorset Marlgrass). Appendix—The determination of nanogram amounts of copper in plant materials using the copper-free apoenzyme of pea-seedling diamine oxidase. *Journal of Experimental Botany* **24**, 525–536.

The changes in activity with age of four copper-containing enzymes—ascorbate oxidase, diamine oxidase, *o*-diphenol oxidase, and cytochrome oxidase—were studied in red clover plants (*Trifolium pratense* L. cv. Dorset Marlgrass) grown in nutrient solutions with and without copper. In the first two weeks after germination the cytochrome oxidase activities were similar although the activities of the other three enzymes were less in the plants grown without than those with copper. At six weeks the activities of all four enzymes were less in plants grown without than those with copper. The copper content of the cotyledons did not change during the first few weeks of growth suggesting that this copper is not easily mobilised.

A new method for determining 1–10 ng amounts of Cu^{2+} is described using the specific reactivation of the copper-free apo-enzyme of pea-seedling diamine oxidase.

6.12 HOLDEN, M. (1973) Chloroplast pigments in plants with the C_4-dicarboxylic acid pathway of photosynthesis. *Photosynthetica* **7**, 41–49.

The chlorophyll *a* : *b* ratio in leaves of C_4 plants, both those with and without grana in bundle-sheath chloroplasts, was greater than in C_3 plants. Bundle-sheath and mesophyll fractions were separated from leaves of six dicotyledons and 20 grasses. In half the species the two fractions had similar *a* : *b* ratios; this was in plants known or presumed to have grana in the bundle-sheath chloroplasts. In the other species the bundle sheath had a larger chl *a* : *b* ratio than the mesophyll; these plants are known or presumed to have agranal chloroplasts. The xanthophyll : carotene ratio was smaller in the bundle sheath than in the mesophyll in three of the four species examined.

6.13 JERVIS, L. (1974) Affinity chromatography of *Nicotiana tabacum* ribonucleases. *Phytochemistry* **13**, 723–727.

The purification of tobacco ribonuclease by affinity chromatography is described. Guanosine 2′,3′-cyclic phosphate, a ribonuclease inhibitor, has been synthesised and insolubilised onto agarose beads. The resulting adsorbent binds tobacco and some other plant ribonucleases strongly but reversibly at pH 5·4. The bound enzyme can be eluted by changing the pH or ionic strength of the eluting buffer, or by specific elution with substrate or inhibitor. Binding is not due to the simple ion-exchange properties of the absorbent.

6.14 JERVIS, L. (1974) Partial purification and characterisation of two *Nicotiana tabacum* leaf ribonucleases. *Phytochemistry* **13**, 709–714.

Two enzymes with similar properties that degrade RNA but not DNA have been partially purified from tobacco leaves. They differ in sub-cellular localisation and in ability to hydrolyse ribonucleoside 2′-3′-cyclic phosphates.

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6.15 JERVIS, L. & PIRIE, N. W. (1974) Ribonucleases in *Nicotiana tabacum* leaf extracts treated with phenol. *Phytochemistry* **13**, 715–721.

When tobacco leaf extracts are treated with phenol, ca 20% of the ribonuclease (RNase) activity survives and can be measured when the phenol is removed. After purification, the resistant RNase is inactivated by phenol; this suggests that tobacco leaves contain material that protects the RNase. Phenol-resistant RNase may be one of the TMV–RNA inactivating systems present in phenol extracts of tobacco leaves.

6.16 MIFLIN, B. J. (1974) Nitrite reduction in leaves; studies on isolated chloroplasts. *Planta* **116**, 187–196.

Chloroplast preparations from spinach leaves containing a high percentage of intact chloroplasts were capable of light dependent nitrite reduction at rates around 9 μmol/mg chlorophyll/hour for periods up to 50 minutes. This reduction was inhibited by DCMU but unaffected by uncouplers of photosynthetic phosphorylation. Nitrite reduction was not accompanied by the stoichiometric evolution of oxygen probably because nitrite or some compound derived from it inhibited oxygen evolution. The disappearance of nitrite was accompanied by an approximately stoichiometric formation of reduced nitrogen.

6.17 (NORRIS, R. D.), LEA, P. J. & FOWDEN, L. (1973) Aminoacyl-tRNA synthetases in *Triticum aestivum* L. during seed development and germination. *Journal of Experimental Botany* **24**, 615–625.

Changes in the level of total and individual aminoacyl-tRNA synthetase activity in the various tissues of wheat (*Triticum aestivum* L.) were followed by the ATP-pyrophosphate (ATP-PP_i) exchange procedure throughout seed maturation and germination.

During seed development the total synthetase activity in the endosperm increased up to the 5th week after fertilisation and thereafter decreased rapidly. Over the same period, synthetase activity in the testa-pericarp decreased markedly, whilst the activity in the developing embryo increased. Many of the individual synthetases conformed with this general pattern although there were several exceptions.

The total synthetase activity of both the coleoptile and coleorhiza (root) increased rapidly during the first two days of germination whilst the total activity of these enzymes in the scutellum remained constant. After an initial increase on germination, aminoacyl-tRNA synthetase activity in the testa-aleurone layer remained almost constant until most of the endosperm had been digested. With a few exceptions the relative levels of individual synthetase in the various tissues did not change significantly during seed maturation or germination.

6.18 PIERPOINT, W. S. (1973) An N-acylamino acid acylase from *Nicotiana tabacum* leaves. *Phytochemistry* **12**, 2359–2364.

An N-acylamino acid acylase was partially purified from tobacco (*Nicotiana tabacum*) leaves and some of its properties are described. It hydrolyses N-acetylarginine, N-acetylmethionine, N-acetylcysteine and to a lesser extent N-formylmethionine. It does not appreciably hydrolyse N-formyl peptides and is therefore unlikely to be involved in protein synthesis.

Plant Pathology Department

THESIS

7.1 ADAMS, M. J. (1973) Development and infection of lenticels on potato tubers during growth and storage. Ph.D. Thesis, London University.

GENERAL PAPERS

7.2 HIDE, G. A. & CORBETT, D. C. M. (1973) Controlling early death of potatoes caused by *Heterodera rostochiensis* and *Verticillium dahliae*. *Annals of Applied Biology* **75**, 461–462.

7.3 HIRST, J. M. (1973) A trapper's line. *Transactions of the British Mycological Society* **61**, 205–213.

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7.4 HIRST, J. M. & HIDE, G. A. (1974) A way to better potatoes? *Arable Farming*, January 1974, pp. 41–45.

RESEARCH PAPERS

7.5 (COUTTS, R. H. A., COCKING, E. C.) & KASSANIS, B. (1972) Infection of tobacco mesophyll protoplasts with tobacco mosaic virus. *Journal of General Virology* **17**, 289–294.

Isolated protoplasts from healthy tobacco mesophyll tissue were infected with a Rothamsted culture of the common strain of tobacco mosaic virus. The average yield of virus/infected protoplast was estimated at 1·4 to 5·8 $\times$ 10^6 particles, which was almost as much as found in intact plants. Virus titre was assessed by infectivity assay, electron microscopy and serological techniques.

7.6 (COUTTS, R. H. A., COCKING, E. C.) & KASSANIS, B. (1972) Infection of protoplasts from yeast with tobacco mosaic virus. *Nature, London* **240**, 466–467.

Equal volumes of *Saccharomyces cerevisiae* protoplast suspension and purified TMV suspension (250 μg/ml were mixed and kept at 28°C for 90 minutes. After removal of unadsorbed virus, yeast protoplasts were incubated for various lengths of time, extracted and infectivity assayed by lesion counts on *Nicotiana tabacum* cv Xanthi. After two to three hours incubation, infectivity had decreased below the levels found in zero time samples. The maximum number of lesions was found after 17–24 hours incubation. Infectivity declined to approximately 50% of the maximum in the 35, 48 and 72 hour samples. Infectivity assays of 10-fold dilutions of zero time extracts indicated that an inhibitor was present.

7.7 GIBSON, R. W. (1974) Aphid-trapping glandular hairs on hybrids of *Solanum tuberosum* and *S. berthaultii*. *Potato Research* **17**, 29–31.

The foliage of hybrids of *S. tuberosum* cv. Pentland Crown and *S. berthaultii* bore four-lobed, glandular hairs which, when ruptured by aphid movements, released a sticky substance which glued the aphids to the plant. The transference of this property makes it more worthwhile testing as a means of decreasing the spread of aphid-borne viruses.

7.8 GIBSON, R. W. (1974) The induction of top-roll symptoms on potato plants by the aphid *Macrosiphum euphorbiae*. *Annals of Applied Biology* **76**, 19–26.
(For Summary see No. 10.38.)

7.9 GOVIER, D. A. & KASSANIS, B. (1974) Evidence that a component other than the virus particle is needed for aphid transmission of potato virus Y. *Virology* **57**, 285–286.

Aphids (*Myzus persicae* Sulz) did not transmit potato virus Y after probing into purified virus preparations, but did if these preparations were first mixed with extracts of infected plants from which all potato virus Y particles had been removed by centrifuging. The same centrifuged extracts also 'helped' aphid transmission of potato aucuba mosaic virus.

7.10 HIDE, G. A., HIRST, J. M. & STEDMAN, O. J. (1973) Effects of black scurf (*Rhizoctonia solani*) on potatoes. *Annals of Applied Biology* **74**, 139–148.

King Edward and Majestic seed tubers, selected as 'clean' (macroscopically symptomless), moderate and severe according to the extent of black scurf, were planted in field experiments at Rothamsted between 1964 and 1968. Seed infection sometimes delayed plants emerging but did not affect final plant populations. Crops from severely diseased seed yielded, on average, 7% less than 'clean' tubers (King Edward 6–8% less and Majestic 0–20% less). Seed infection affected tuber size distribution; compared with 'clean' seed, severely infected King Edward seed yielded slightly more chats (<1½in, 3·8 cm) and 1·5 ton/acre (3·8 t/ha) less large tubers (2¼–3¼ in, 5·7–8·3 cm). The effects were similar with Majestic although differences were smaller. However, total yields from diseased stocks (unselected) seldom differed significantly from the 'clean' tubers selected from them. Crops from moderately and severely diseased seed had more Corticium on stems and black scurf on tubers and usually less *Oospora pustulans* than from 'clean' seed.

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7.11 JAMES, M., KENTEN, R. H. & WOODS, R. D. (1973) Virus-like particles associated with two diseases of *Colocasia esculenta* (L.) Schott in the Solomon Islands. *Journal of General Virology* **21**, 145–153.

Bacilliform virus-like particles of two sizes are found associated with the diseases 'Alomae' and 'Bobone' of *Colocasia esculenta* in the Solomon Islands. Neither kind of particle was transmitted mechanically or by aphids. The smaller particles were similar in size and shape to cocoa swollen-shoot virus and measured 125 × 28 to 29 nm in negative stain. In partially purified preparations their sedimentation coefficient was 285S. In thin sections of diseased *C. esculenta* they were found in the cytoplasm of phloem sieve tubes loosely aggregated with amorphous material, or packed closely, but haphazardly, in bundles. The larger particles were found in sieve tubes, companion cells and mesophyll. They measured 300 to 335 × 50 to 55 nm and in transverse sections showed three electron-dense layers, a central core about 9 nm in diameter, an inner annulus approximately 28 nm thick and an outer annulus 3 to 5 nm thick. Large particles were found in the perinuclear space but not within the inner nuclear membrane; they were associated with 'viroplasms' and occurred commonly in membrane-bound vesicles. They apparently matured by budding from cytoplasmic membranes.

7.12 JENKYN, J. F. & PREW, R. D. (1973). Activity of six fungicides against cereal foliage and root diseases. *Annals of Applied Biology* **75**, 241–252.

During 1970 and 1971 six systemic fungicides were compared as seed dressings and sprays against foliage and root diseases of cereals. The fungicides differed greatly in effectiveness against mildew, loose smut, rusts and eyespot but none controlled take-all. Effects were also noted on germination, seedling growth and leaf-surface microflora.

7.13 JENKYN, J. F. & PREW, R. D. (1973) The effect of fungicides on incidence of *Sporobolomyces* spp. and *Cladosporium* spp. on flag leaves of winter wheat. *Annals of Applied Biology* **75**, 253–256.

Sprays of benomyl, thiophanate methyl, 'NF 48' and captafol considerably decreased incidence of *Sporobolomyces* spp. and *Cladosporium* spp. on flag leaves of winter wheat. 'BAS 3170 F' affected both genera but much less. Tridemorph and triforine had relatively little effect on *Sporobolomyces* spp. but tridemorph did decrease *Cladosporium* spp. 'Sandoz 52.133' affected only *Cladosporium* spp. and ethirimol affected neither genus.

7.14 KASSANIS, B., WHITE, R. F. & WOODS, R. D. (1973) Genetic complementation between middle and bottom components of two strains of radish mosaic virus. *Journal of General Virology* **20**, 277–285.

Kale virus (KV), turnip virus (HZ) and radish mosaic virus (RMV) are slightly related serologically to cowpea mosaic virus. Purified preparations comprise, top, middle and bottom components, of which only the last two contain nucleic acid. The nucleo-protein components of each virus were separated by centrifuging twice through a sucrose gradient in an MSE BXIV zonal rotor. Sometimes this was followed by centrifuging to equilibrium in a density gradient of rubidium bromide. Neither nucleoprotein component was infective alone, but infectivity was restored when each was mixed with the other component.

Mixtures in which the two components came from different viruses were infective only when they were made with KV and HZ. Serologically these two viruses are more closely related than either is to RMV. KV differed from HZ by two characters related to the coat protein. KV particles regularly formed aggregates of 12 particles and contained antigens that were not present in HZ. Single lesion isolates from mixtures of bottom component from one strain and middle component from the other did not form aggregates and lacked the antigens present in KV. Like cowpea mosaic virus, KV and HZ each have two coat proteins, and our results can be explained if each of the four virus components codes for a different coat protein. Therefore, the coat protein of the virus is coded by the nucleic acid of both middle and bottom components.

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7.15 LACEY, J. (1973) The air spora of a Portuguese cork factory. *Annals of Occupational Hygiene* **16**, 223–230.

Cork particles and fungus spores were commonly airborne in a cork factory in Portugal where some workers suffered from suberosis. Where cork was being handled and shaped, fungus spores were usually more common than cork particles. In a warehouse (fundao) where cork had moulded, up to 54×10^6 spores/m^3 were general in the air, but workers handling the mouldy cork were exposed to as many as 128×10^6 spores/m^3. Cork particles were most common close to cutting and sanding machines, but seldom exceeded 2×10^6 particles/m^3 air. The most abundant species were *Penicillium frequentans* Westling, *P. granulatum* Bain., *Aphanocladium album* (Preuss) W. Gams, *Monilia sitophila* (Mont.) Sacc. and *Mucor plumbeus* Bon., *P frequentans* was common everywhere in the factory and mostly in units small enough to penetrate into alveoli.

7.16 LACEY, J. (1974) Moulding of sugar-cane bagasse and its prevention. *Annals of Applied Biology* **76**, 63–76.

When fresh sugar-cane bagasse containing about 50% water and 3% sugar was baled and stacked, it quickly heated to over 50°C and remained hotter than 40°C for 50 days. The residual sucrose was utilised by microbial growth and the content of fungal, bacterial and actinomycete spores increased to more than 10^8/g dry wt. The spores in heated bagasse were mostly of thermophilic actinomycetes and fungi, and included two actinomycetes implicated in bagassosis. *Thermoactinomyces sacchari* occurred in 40% of samples examined, some of which yielded up to 5×10^6 colonies/g, while *T. vulgaris* occurred in 80% of samples, but these rarely yielded more than 10^5 colonies/g. Other organisms were cellulolytic and caused fibre deterioration. Heating and moulding could be much decreased either by drying to about 25% water content, which halved the spore content after storage, mostly at the expense of the actinomycetes, or by adding 2% by weight of propionic acid, which decreased the spore content to 4×10^6 spores/g or less even after 18 months' storage. Sometimes adding only 0·6% of propionic acid or 2% of propionic acid applied as a 50% aqueous solution had a similar effect. Treatment with propionic acid thus decreased the deterioration of bagasse, permitted its storage between harvests and prevented the hazard of bagassosis to workers.

7.17 MILNE, R. G. (1972) Pseudocrystalline bodies in the chloroplasts of isolated protoplasts and of incubated leaf discs. *Botanical Gazette* **133**, 401–404.

Ragetli, Weintraub and Lo described 'pseudocrystalline bodies' in chloroplasts of detached *Nicotiana glutinosa* leaves that had been kept under natural illumination for several days with their petioles in water. Similar structures are reported from protoplasts isolated from tobacco leaves and from tobacco leaf discs floated on water.

7.18 PEARSON, V., BROWN, M. E. & HORNBY, D. (1973) Some observations on microbial populations and nitrogen in soils infested with the take-all fungus. *Pesticide Science* **4**, 397–398.

(For summary see No. 4.7.)

7.19 PLUMB, R. T. (1974) Properties and isolates of barley yellow dwarf virus. *Annals of Applied Biology* **77**, 21–25.

Barley yellow dwarf virus is persistently transmitted by a number of aphid species of which three, *Rhopalosiphum padi*, *Sitobion avenae* and *Metopolophium dirhodum*, are common in most years. Other aphids may be locally important. Isolates of the virus differ in their virulence and geographical distribution and are not transmitted equally well by all aphid vectors. Isolates with similar properties are grouped into strains according to their transmission by vectors and their severity. Changes in strain and aphid occurrence from year to year alter the incidence of virus and its effect on yield. These changes emphasise the need for detailed knowledge of cereal aphid biology and epidemiology of BYDV before effective control can be used.

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7.20 PLUMB, R. T. & JAMES, M. (1972) Virus aggregates and pin-wheels in plants infected with mite-transmitted ryegrass mosaic virus. *Journal of General Virology* **18**, 409–411.

Electron microscopy of ryegrass mosaic virus infected *Lolium multiflorum* and *Avena sativa* leaves showed aggregation of virus in some tissues although a few unaggregated particles occurred in some cells. Most virus particles were restricted to the mesophyll tissue and were never seen in vascular tissue or adjacent cells. Infected cells became vacuolate and degenerate. Sections also showed frequent pinwheels and lamina cell inclusions, indicating, at least in its ultra-structural effects on infected cells, that ryegrass mosaic virus showed affinities with the potato virus Y (PVY) group. The significance of the above observations are discussed in relation to the definition and delimitation of the PVY group, and it is concluded that, although pinwheels remain diagnostic for infection by viruses with elongated particles, other characteristics of the virus, especially the vector, may not correspond to those associated with the PVY group. Specifically, pinwheel inclusions need not necessarily be associated with an aphid vector.

7.21 RAWLINSON, C. J. & (MACLEAN, D. J.) (1973) Virus-like particles in axenic cultures of *Puccinia graminis tritici*. *Transactions of the British Mycological Society* **61**, 590–593.

Puccinia graminis Pers. f. sp. *tritici* Erikss & E. Henn. often fails to grow in axenic culture from urediniospores, and isolates of this fungus which do grow may produce a range of very different colonies. A range of variants (V1A [senescing], V1A [non-senescing], V1B, V1B/S, V1B/L, V1C, V2A, V2B, V2C, V2D, V3A, V3B and V7) which arose spontaneously from race 126-ANZ-6, 7 had been maintained in culture for up to five years. They were either mono- or dikaryotic and differed in growth rate, morphology, texture, pigmentation and mode of senescence; variants also differed in pathogenicity on wheat. The cause of the differences is unknown, but as some were similar to differences attributed to virus infection, we examined these cultures for virus particles. Isometric virus-like particles (VLP), c. 38 nm diameter were seen in extracts from every variant except from completely senesced colonies of V1A [senescing] and were located in the cytoplasm of hyphae. Most VLP in mycelial extracts, and some in the sectioned hyphae, were 'empty', presumably empty protein shells. The yield of VLP was small (estimated at 0·1 mg/100 g fresh mycelium) so it has been difficult to characterise them fully. Their sedimentation coefficients (s°20, w) were 110S and 58S, but three components separated in caesium chloride and rubidium bromide with buoyant densities of 1·31, 1·30 and 1·29 g/cm^3. Similar VLP were found in mycelium and urediniospores of an English isolate of rust (race 21) whose urediniospores, like those of race 126, infrequently grew in axenic culture.

7.22 RAWLINSON, C. J., HORNY, D., PEARSON, V. & CARPENTER, J. M. (1973) Virus-like particles in the take-all fungus, *Gaeumannomyces graminis*. *Annals of Applied Biology* **74**, 197–209.

Isometric virus-like particles (VLP) measuring 35 nm and 27 nm occurred in cultured mycelium of *Gaeumannomyces graminis* var. *tritici* and *G. graminis* var. *avenae*. These VLP had, respectively sedimentation coefficients (s°20, w) 148S and 110S and ultra-violet absorption (maximum 260 nm, minimum 240 nm) typical of nucleoprotein (A260 : 280 = 1·6, A260 : 240 = 1·2). Preparations of the 35 nm particles had two major and one minor component in caesium chloride, and 27 nm particles had two components (buoyant densities 1·37, 1·36, 1·30, 1·35 and 1·29 g/cm^3 respectively). Preparations of the 35 nm particles or 35 nm plus 27 nm particles had one major protein species with estimated molecular weight 70 000 daltons.

The 35 nm VLP were absent from 11 isolates of *G. graminis* var. *tritici* from first cereal crops after fallow or non-susceptible break crops; two of these contained the 27 nm particles. More than half of 145 isolates, from cereals after 2–12 consecutive susceptible crops, contained either 35 nm or 27 nm VLP. VLP were not confined to *G. graminis* isolates from soils exhibiting 'take-all decline' nor consistently associated with weak pathogenicity or with isolates of unusual growth, morphology, pigmentation, lysis or readiness to form perithecia. Isolates with one kind of particle were mostly more pathogenic and those with both kinds less pathogenic than isolates without VLP. The proportion of isolates with 27 nm and 35 nm particles increased progressively in samples from different consecutive crops during the first nine years of cropping, then decreased.

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Isolates did not gain or lose VLP during infection and re-isolation from wheat seedlings grown in sand.

Four 'infected' isolates were freed from VLP either by culturing ascospores or by growing hyphal tips excised from colonies kept near their thermal death point. Both VLP appeared in cultures which had undergone anastomosis with infected isolates.

7.23 SAHAMBI, H. S., MILNE, R. G., COOK, S. M., GIBBS, A. J. & WOODS, R. D. (1972) Broad bean wilt and nasturtium ringspot viruses are related. *Phytopathologische Zeitschrift* **76**, 158–165.

There have been several reports of viruses being isolated in different parts of the world from nasturtium plants (*Tropaeolum majus* L.) showing mosaic, mottling and ringspot symptoms. These include nasturtium ringspot virus, nasturtium mosaic virus and Ringmosaik-Virus der Kapuzinerkresse. All had moderate or wide host ranges, were inactivated in sap at 50–60°C in 10 minutes and were transmitted by sap inoculation and by aphids in the non-persistent manner. There have been no reports of the morphology of the particles of these viruses nor were antisera prepared against them, and all except one of the original isolates have been lost from culture. However, nasturtium plants showing ringspot symptoms are widespread in Europe and a virus was isolated from nasturtium plants near Bonn, West Germany. This virus had all the known properties of nasturtium ringspot virus (NRSV) and has been shown by A. F. Murant to be closely serologically related to parsley virus 3 which, in turn, is serologically indistinguishable from the present culture of NRSV isolated by Smith in 1950 and maintained by the John Innes Institute.

Preliminary tests suggested that our virus was related to broad bean wilt virus, which is found in Australia and Japan. Further experiments showed that NRSV and broad bean wilt virus (BBWV) are closely similar or the same.

7.24 WHITE, R. F., KASSANIS, B. & WOODS, R. D. (1973) Isopycnic banding of strains of radish mosaic virus in rubidium bromide solutions. *Journal of General Virology* **20**, 387–389.

Strains KV and HZ of radish mosaic virus when centrifuged to equilibrium in caesium chloride gave four bands, although they have only two nucleoprotein components. However, when centrifuged to equilibrium in rubidium bromide, HZ gave only two major bands and KV gave these and several extra small bands, presumably because this strain contains aggregates of 12 particles derived from all three components and therefore having different densities from the nucleoprotein components.

Nematology Department

BOOK

8.1 JONES, F. G. W. & JONES, M. G. (1974) *Pests of field crops.* 2nd Edition. London: Edward Arnold, 450 pp.

THESIS

8.2 KERRY, B. R. (1973) Population studies of the cereal cyst-nematode, *Heterodera avenae* Woll. Ph.D. Thesis, University of Reading.

FILMS

8.3 NUTMAN, P. S., DONCASTER, C. C. & DART, P. J. (1973) *Infection of clover by root-nodule bacteria.* London: British Film Institute.

8.4 DONCASTER, C. C. (1973) *Theratromyxa weberi* (*Proteomyxida*). Goettingen: Encyclopaedia Cinematographica. E.2034.

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General Papers

8.5 Bromilow, R. H. (1973) Breakdown and fate of oximecarbamate nematicides in crops and soils. *Annals of Applied Biology* **75**, 473–479.

8.6 Corbett, D. C. M. (1973) *Pratylenchus penetrans. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 2, No. 25.

8.7 Corbett, D. C. M. & Clark, S. A. (1973) Surface features of the head in *Pratylenchus* spp. *Second International Congress of Plant Pathology, Minnesota USA. Abstract* No. 393.

8.8 Hide, G. A. & Corbett, D. C. M. (1973) Controlling early death of potatoes caused by *Heterodera rostochiensis* and *Verticillium dahliae. Annals of Applied Biology* **75**, 461–462.

8.9 Hooper, D. J. (1973) *Longidorus elongatus. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 2, No. 30.

8.10 Hooper, D. J. (1973) *Ditylenchus destructor. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 2, No. 21.

8.11 Hooper, D. J. (1973) Identification of *Longidorus* and *Paralongidorus* species found in the British Isles. In: The Longidoridae Workshop Manual, *Association of Applied Biologists*, Nematology Group, pp. 11–36, Harpenden, Rothamsted exp. Stn, 70 pp.

8.12 Hooper, D. J. & (Southey, J. F.) (1973) The Longidoridae. *Ibidem*, pp. 3–10.

8.13 Jones, F. G. W. (1974) Background to biological control of nematode pests. In: *Biology in pest and disease control.* Ed. D. P. Jones & M. E. Solomon. *British Ecological Symposium, Oxford.* Blackwell Scientific Publications, pp. 249–268.

8.14 Stone, A. R. (1973) *Heterodera pallida. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 2, No. 17.

8.15 Stone, A. R. (1973) *Heterodera rostochiensis. Commonwealth Institute of Helminthology. Descriptions of plant-parasitic nematodes.* Set 2, No. 16.

8.16 Whitehead, A. G. (1973) Control of cyst-nematodes (*Heterodera* spp.) by organophosphates, oximecarbamates and soil fumigants. *Annals of Applied Biology* **75**, 439–453.

8.17 Whitehead, A. G. (1974) Nematicides for temperate crops. *Proceedings of the 7th British Insecticide and Fungicide Conference, Brighton (1973)* **3**, 955–962.

Research Papers

8.18 Clark, S. A., Shepherd, A. M. & Kempton, A. (1973) Spicule structure in some *Heterodera* spp. *Nematologica* **19**, 242–247.

Observations on spicule structure of 11 species of *Heterodera* confirmed that the spicule tips of *H.* (*Heterodera*) were basically bifid whereas those of *H.* (*Globodera*) were single. In all species there were two small pores close to each spicule tip. Sections through the spicules showed that they contained a large nerve which tapered towards the spicule tip where two dendritic elements were associated with the pores. The interlocking wings of the spicule blades form a tubular structure through which sperm can be transferred when spicules are inserted into the female reproductive tract. In mating, the spicules probably also have a sensory function.

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8.19 DONCASTER, C. C. (1973) *Heterodera rostochiensis* (*Nematoda*). *Egg hatch.* Goettingen: Encyclopaedia Cinematographica, E2035.

Heterodera rostochiensis larvae in their eggs respond to potato-root exudates by increasing their locomotory activity and producing gland secretions. Emergence from the egg is by cutting an exit slit with the mouth stylet. In the artificial hatching stimulant, sodium metavanadate, ovic larvae perforate but do not cut the egg shell with the stylet; the shell softens and emergence is by the larva rupturing it. The processes are illustrated by film.

8.20 DONCASTER, C. C. & SEYMOUR, M. K. (1973) Egg-transport in the genital tract and egg-laying by *Aphelenchoides blastophthorus*. *Nematologica* **19**, 379–388.

In *A. blastophthorus* ova are moved down the ovary by their growth and by the kneading action of body-wall muscles. Once the shell is formed, the egg impedes the flow of fluid gut and uterine wall tissues resulting in a net transfer of fluid tissues forward and a corresponding backward displacement of the egg. Eggs were usually laid from the uterus but sometimes from the post-vulval sac. Contraction of the somatic muscles increased the body pressure which forced the egg through the vagina and vulva as they were opened by their own muscles. When sperms are unconstrained they are basically spheroidal, but in the uterus they are compressed into stacks of discs.

8.21 DONCASTER, C. C. & SEYMOUR, M. K. (1973) Exploration and selection of penetration by Tylenchida. *Nematologica* **19**, 137–145.

Filmed observations of 11 tylenchid species show the same basic pattern of behaviour leading to feeding. Simple sequences of behaviour initiated in response to stimuli lead to egg-hatching and host penetration. Searching behaviour, stimulated chemically by a host, includes locomotion, head movements and probing with the stylet. It found favourable, the cell surface is penetrated by stylet thrusting, during which the body and head are held immobile and the lips are pressed against the surface. On a food-cell, feeding follows. In cutting an aperture, stylet thrusting results in a slit being formed through which the nematode then passes.

8.22 (MALI, V. R.) & HOOPER, D. J. (1974) Observations on *Longidorus euonymus* n.sp. and *Xiphinema vuittenezi* Luc *et al.*, 1964 (Nematoda : Dorylaimida) associated with spindle trees infected with euonymus mosaic virus in Czechoslovakia. *Nematologica* **19**, 459–467.

Around Bratislava *Longidorus euonymus* n.sp. is found with *Xiphinema vuittenezi* in the rhizosphere of *Euonymus europaeus* which is often infected with euonymus mosaic virus. *L. euonymus* n.sp. resembles *L. closelongatus* and *L. cohni* but has a much shorter odontostyle than either and a fatter body than *L. cohni*. It also resembles *L. vineacola* but has a more offset lip region, shorter odontostyle and relatively longer female tail. It is larger than *L. attenuatus* and *L. elongatus* and has a more offset lip region than *L. elongatus* and a wider and more bluntly rounded female tail than either of these species. Juveniles and females of *L. euonymus* acquired EMV from mechanically inoculated cucumber-plants and transmitted it to healthy cucumber-plants but juveniles and females of *X. vuittenezi* failed to do so. *L. euonymus* was not necessarily responsible for the incidence of EMV on Spindle trees because the fungus *Olpidium brassicae*, that transmits this virus was present also at most sites.

8.23 SHEPHERD, A. M., CLARK, S. A. & KEMPTON, A. (1974) Spermatogenesis and sperm ultrastructure in some cyst nematodes, *Heterodera* spp. *Nematologica* **19**, 551–560.

In both round and lemon-shaped species of cyst-nematodes, the early stages of spermatogenesis were completed in the fourth stage larva and no further cell divisions took place after the last moult. Only spermatids and spermatozoa were present in adult males; in old males the whole gonad was occupied by mature sperm. *Heterodera* sperm resemble other nematode sperms in some respects but differ in others, notably in possessing a layer of cortical micro-tubules lining the whole surface of the sperm, including the pseudopodia and filopodia. In round-cyst nematodes the condensation of the sperm nucleus changes several times during spermiogenesis and

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insemination. In lemon-shaped cyst-nematodes the nucleus does not pass through the finely stranded phase in the testis, a difference distinguishing the two main groups of cyst-nematodes.

8.24 STONE, A. R. & WILLIAMS, T. D. (1974) The morphology and soluble protein electrophoresis of *Heterodera avenae* pathotypes. *Annals of Applied Biology* **76**, 231–236.

Examination of the larvae, females and cysts of pathotypes 1 and 2 of *H. avenae* failed to reveal differences that could be used to distinguish between them, nor were usable differences in the soluble proteins revealed by electrophoresis in polyacrylamide gels. Evidently both pathotypes belong to the same species.

8.25 WEBB, R. M. & CORBETT, D. C. M. (1973) The effect of phorate on nematode populations in wheat grown continuously in ploughed and unploughed soil. *Soil Biology & Biochemistry* **5**, 585–591.

Phorate granules applied to soil in autumn before planting and again in spring decreased the numbers of *Pratylenchus* spp. in roots of wheat and in surrounding soil, and decreased the numbers of all other nematodes, except Dorylaims, in soil of ploughed and unploughed plots. *Tylenchorhynchus* spp. and Dorylaims were more and *Paratylenchus* spp. less numerous in ploughed soil. Grain yields decreased after the second wheat crop, and the mean number of most nematodes decreased during the experiment.

8.26 WHITEHEAD, A. G., TITE, D. J., FRASER, J. E. & FRENCH, E. M. (1973) Control of potato cyst-nematode, *Heterodera rostochiensis*, in sandy, peaty and silt loam soils by dazomet and 'Telone' applied in different ways. *Annals of Applied Biology* **75**, 257–265.

Dazomet or 'Telone' controlled potato cyst-nematode, *Heterodera rostochiensis*, as well when applied to potato ridge soil in autumn as when applied to it in spring but dazomet was more effective than 'Telone'. Dazomet incorporated in autumn in ridges of peaty loam greatly increased yields of King Edward potatoes the following year and nematode multiplication was greatly reduced compared with untreated soil. Two equal dressings of dazomet, one incorporated in the top soil before, the other after ploughing, controlled potato cyst-nematode as well as an equivalent single dressing incorporated after ploughing, but increased yield of King Edward potatoes more. In silt loam two dressings of dazomet, similarly applied, controlled the nematode better than the equivalent amount applied as a single dressing after ploughing, and the nematode was controlled best by two large dressings of dazomet or a combined treatment of dazomet and 'Telone'.

Insecticides and Fungicides Department

GENERAL PAPERS

9.1 (CHERRETT, J. M., PEREGRINE, D. J.), ETHERIDGE, P., MUDD, A. & PHILLIPS, F. T. (1973) Some aspects of the development of toxic baits for the control of leaf-cutting ants. *Proceedings of the 7th International Congress of the International Union for the Study of Social Insects, London, September 1973*, pp. 69–75.

9.2 DEVONSHIRE, A. L. (1973) The biochemical mechanisms of resistance to insecticides with especial reference to the housefly, *Musca domestica* and aphid, *Myzus persicae*. *Pesticide Science* **4**, 521–529.

9.3 ELLIOTT, M. & JANES, N. F. (1973) Chemistry of the natural pyrethrins. In: *Pyrethrum —the natural insecticide*. Ed. J. E. Casida. New York: Academic Press, pp. 56–100.

9.4 GRAHAM-BRYCE, I. J. (1974) Cereal seed dressings, problems and progress. *Proceedings of the 7th British Insecticide and Fungicide Conference, Brighton, 1973*, **3**, 921–932.

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9.5 POTTER, C. (1973) Radioisotopes to estimate the dispersal of insecticides in the environment and irradiation techniques for the study of insect populations. *Proceedings of Symposium on the Use of Isotopes and Radiation in Agriculture and Animal Husbandry Research*, Delhi, December 1971.

9.6 SAWICKI, R. M. (1973) Recent advances in the study of the genetics of resistance in the housefly, *Musca domestica*. *Pesticide Science* **4**, 501–512.

9.7 STEVENSON, J. H. (1972) Insecticides and beekeeping in England. *Lecture to Central Association of Bee-keepers, 9 February 1972.*

RESEARCH PAPERS

9.8 ARNOLD, A. J., NEEDHAM, P. H. & STEVENSON, J. H. (1973) A self-powered portable insect suction sampler and its use to assess the effects of azinphos methyl and endosulfan on blossom beetle populations on oil seed rape. *Annals of Applied Biology* **75**, 229–233

A new portable insect suction sampler, powered by a small petrol engine, is described. It has been in use for three seasons, and examples given of samples taken from oil-seed rape demonstrate that the suction method is more informative than visual counts or sweep-net sampling for assessing blossom beetle populations.

9.9 (BAIG, M. M. H., KHAN, M. S., KHAN, N., FERHAT, S., HOSSAIN, A., OSMANI, M. J. A.) & LORD, K. A. (1972) Gas chromatographic and radiometric study of the behaviour of C^{14}-DDT on mustard plants under tropical conditions. *Pakistan Journal of Scientific and Industrial Research* **15**, 220–226.

The behaviour of a DDT emulsifiable concentrate sprayed onto mustard plants was examined under tropical conditions using chemical and radiochemical techniques. The steady loss of DDT from the surface of leaves, measured as surface radio-activity, was closely similar to the loss assessed by washing the insecticide from leaves with hexane and measuring it by gas chromatography and radiometry. About one-quarter remained on leaf surfaces two days after spraying and less than one-tenth remained after ten days.

After two to four days about one quarter of the DDT had penetrated into leaves, as shown both by chemical and radiochemical measurements of insecticide which could be extracted from leaves after washing the surfaces with hexane. The amount of DDT in the plant diminished with time although radiometric assay indicated a faster loss than chemical assay.

Most of the radioactivity found appeared to be present as DDT although there was gas chromatographic evidence of some slight degradation of DDT. It is concluded that loss was mainly by volatilisation.

9.10 DEVONSHIRE, A. L. & NEEDHAM, P. H. (1974) The fate of some organophosphorus compounds applied topically to peach-potato aphids (*Myzus persicae* (Sulz.)) resistant and susceptible to insecticides. *Pesticide Science* **5**, 161–169.

The fate of [^{14}C]dimethoate and [^{14}C]parathion after topical application to strains of *Myzus persicae* resistant and susceptible to organophosphorus compounds was investigated. In 4 hours approximately 65% of the dimethoate or parathion applied was lost from the aphids by evaporation, and this limited the amount available for penetration into the insect. Only approximately 25% of the dose applied penetrated, of which a very small proportion was excreted as metabolites. There was no difference in the amounts penetrating into the resistant and susceptible strains, indicating that penetration was not a factor contributing to the observed resistance. These findings emphasise that evaporation from the cuticle can greatly influence results when insecticides are applied topically.

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9.11 ELLIOTT, M., FARNHAM, A. W., JANES, N. F., NEEDHAM, P. H. & PULMAN, D. A. (1973) Potent pyrethroid insecticides from modified cyclopropane acids. *Nature, London* **244**, 456–457.

Novel substituents on the 3-position of the cyclopropane ring of bioresmethrin give analogues that are up to 2·7 times more active against insects. Mammalian toxicity is not influenced markedly by the change in structure; this fact prompts discussion of the relative importance of known routes of metabolism.

9.12 ELLIOTT, M., FARNHAM, A. W., JANES, N. F., NEEDHAM, P. H., PULMAN, D. A. & STEVENSON, J. H. (1973) A photostable pyrethroid. *Nature, London* **246**, 169–170.

The easily synthesised mixture of isomers of 2,2-dimethyl-3-(2,2-dichlorovinyl)-cyclopropane carboxylic acid contains the very effective acid (the (+)-*trans* isomer) discovered previously. The mixture (20 : 80 *cis* : *trans*) gives, with 3-phenoxybenzyl alcohol, an insecticidal ester, NRDC 143, more stable to light and air than bioresmethrin and pyrethrin I. The light-sensitive groups in both the acid and the alcohol sides of the molecule have been replaced by more stable groups.

9.13 ELLIOTT, M., FARNHAM, A. W., JANES, N. F., NEEDHAM, P. H., PULMAN, D. A. & STEVENSON, J. H. (1974) NRDC 143, a more stable pyrethroid. *Proceedings of the 7th British Insecticide and Fungicide Conference, Brighton, 1973*, pp. 721–728.

A recently developed synthetic pyrethroid, NRDC 143 [3-phenoxybenzyl (±)-*cis,trans*-2,2-dimethyl-3-(2,2-dichlorovinyl)cyclopropane carboxylate] is 10–100 times more stable in light than previous pyrethroids, is more active against insects than resmethrin, and has low mammalian toxicity.

9.14 ELLIOTT, M., JANES, N. F. & (SPANNER, J. A.) (1973) The pyrethrins and related compounds. XVII. Preparation of the insecticide bioresmethrin (5-benzyl-3-furylmethyl (+)-*trans*-chrysanthemate) and related compounds labelled with deuterium or tritium on the furan ring. *Pesticide Science* **4**, 677–681.

2-^{2}H-5-Benzyl-3-furylmethyl esters exclusively are obtained from an exchange reaction of the parent esters with deuterium oxide and a trace of acid (n.m.r. and mass spectrometric control). Similarly, with tritiated water, six insecticidal esters of 5-benzyl-3-furylmethyl alcohol give the corresponding [2-^{3}H] esters, each with specific activity of approx. 500 mCi/mmol.

9.15 FARNHAM, A. W. (1973) Genetics of resistance of pyrethroid-selected houseflies, *Musca domestica* L. *Pesticide Science* **4**, 513–520.

Four resistance factors were isolated genetically from the *NPR* strain of houseflies (*Musca domestica* L.), which resists natural pyrethrins, and were characterised toxicologically. The four factors were: *pen*, which reduces the rate of penetration of insecticides through the cuticle; *kdr-NPR*, a general pyrethroid resistance mechanism unaffected by the synergist sesamex; *py-ses*, a mechanism of resistance to natural pyrethrins that can be suppressed by sesamex; and *py-ex*, a factor that gives strong resistance to synergised natural pyrethrins and to the new synthetic esters, e.g. resmethrin, but little or none to natural pyrethrins alone.

9.16 GREENWAY, A. R. & GRIFFITHS, D. C. (1973) A comparison of triglycerides from aphids and their cornicle secretions. *Journal of Insect Physiology* **19**, 1649–1655.

Direct mass spectrometry of extracts showed that body triglycerides from 30 species of aphids contained the same fatty acid radicals, C_6 (hexanoyl), $C_{6:2}$ (sorboyl), C_{14} (myristoyl) and C_{16} (palmitoyl) as did the cornicle secretions, but in many species the proportions of hexanoyl and/or palmitoyl triglycerides were greater in the body. When cornicle secretions were collected progressively so as to draw increasingly upon body fat reserves, their composition changed gradually towards that of the body extracts.

All summer forms of *Myzus persicae* had similar body triglycerides, even when selected for resistance to organophosphorus insecticides, or bred for three months on an artificial diet. The

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composition of body triglycerides was also independent of colour in two aphid species in which pink and green forms were compared.

Body extracts contain enough triglycerides for their composition to be determined in single aphids and the use of body extracts allows examination of aphids lacking cornicles and of specimens that do not give cornicle secretion because of low body turgor. Although, as in the case of cornicle secretions, the triglyceride composition of body extracts was not well correlated with taxonomic position, body extracts provide a second chemical characteristic that can be used to define a particular species.

9.17 GREGORY, G. E. (1974) Neuroanatomy of the mesothoracic ganglion of the cockroach *Periplaneta americana* (L.). I. The roots of the peripheral nerves. *Philosophical Transactions of the Royal Society of London* B **267**, 421–465.

The general neuroanatomy and details of the nerve roots in the mesothoracic ganglion of adult males of *Periplaneta americana* (L.) were examined using Bodian silver-stained sections and Procion Yellow impregnation. General structure of the ganglion is summarized and the basic plan of its tracheation outlined. Fresh details are given of the seven paired longitudinal fibre tracts and ten transverse commissures, and three new oblique tracts of characteristic shape are described: the ring tract, C-tract and I-tract. Regions of the ventral association centre are briefly described. Groups of neuron cell bodies, which lie peripherally in the ganglion, are designated according to position. The fibre bundles that form the roots of each of the six paired peripheral nerves (nerves 2 to 7) and the single median nerve (nerve 8) are numbered from dorsal to ventral and their courses and fibre composition described. In all, 30 roots are characterized on each side of the ganglion, containing over 150 efferent, presumed motor, fibres and over 2000 afferent, presumed sensory, fibres. Function and fibre diameter are not consistently related and almost all sizes of both motor and sensory fibres occur. Nerves 2 and 6 divide into distinct dorsal and ventral roots; the roots of nerves 4 and 8 are dorsal and of nerve 7 solely ventral; roots of nerves 3 and 5 form fairly continuous series from dorsal to ventral. The more dorsal nerve roots tend to be motor in function and the ventral roots sensory. Nearly all motor cell bodies are located ventrally or ventrolaterally and their processes run more or less dorsally to give off dendritic branches into dorsal or lateral neuropile before sending axons peripherally in the nerve trunks. Cell bodies of nerves 3 to 6, except for one in the midline, are ipsilateral, those of nerves 3 and 4 lying almost wholly anteriorly and of nerves 5 and 6 both anteriorly and posteriorly. Cell bodies of nerve 2 are contralateral and anterior except for one in the dorsal midline. Nerve 8 receives axons from posterior cell bodies of both sides. An apparently common inhibitory motoneuron branches to nerves 3, 4, 5 and 6. The topology of some other motoneurons, chiefly of nerves 4 and 5, is outlined and the probable correspondence of some of them with previously identified metathoracic neurons is discussed. Sensory roots, predominantly of very small fibres, of nerves 2, 3, 5, 6 and 7 enter the ventral association centre. Mainly coarser sensory fibres branch into mid-level neuropile or below, though some of those of nerves 2, 3 and 7 ascend more dorsally.

9.18 GRIFFITHS, D. C. & SMITH, CLARA (1973) The insecticidal activity of diethyl and dimethyl analogues of azinophos, bromophos, carbophenothion and parathion on glass surfaces and in soil. *Pesticide Science* **4**, 335–342.

The insecticidal activity of dimethyl and diethyl forms of parathion, carbophenothion, bromophos and azinphos on glass surfaces and in soil was assessed by bioassay with adult vestigial winged *Drosophilia melanogaster* (Meig.). Both on glass and in soil there were large differences in the initial toxicities of the four different pairs of insecticides, but little difference between diethyl and dimethyl forms of each compound. In soil, toxicity was influenced greatly by soil type and moisture content, decreasing in the order moist sand = dry sand > moist clay-loam > dry clay-loam > dry peat > moist peat. Some of these effects may have been caused by differences in the behaviour of insects confined with moist or dry treated soils.

In sterilised or unsterilised moist clay-loam, diethyl forms of three of the four compounds remained toxic longer than their dimethyl counterparts. Possibly such differences could account for the greater effectiveness of certain diethyl compounds in field control of soil insect pests.

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9.19 JANES, N. F. (MACHIN, A. F., QUICK, M. P., ROGERS, H., MUNDY, D. E. & CROSS, A. J.) (1973) Toxic metabolites of diazinon in sheep. *Journal of Agricultural and Food Chemistry* **21**, 121–124.

Diazinon is oxidised in sheep to several cholinesterase-inhibiting metabolites. The structures of three of them were determined by direct spectroscopic measurements. Two are monohydroxy diazinons, and the third is a dehydration product of one of these; the three structures had already been proposed for diazinon metabolites produced by mice, when the establishment of structure was based on cochromatography with synthetic samples. Some quantitative aspects of the distribution of the compounds in sheep were reported.

9.20 JEFFS, K. A. (1974) Pretreatment of cereal seeds before the use of insecticidal powders. *Proceedings 7th British Insecticide and Fungicide Conference, Brighton, 1973*, pp. 341–348.

Powder formulations for seed treatments do not adhere strongly to cereal seeds so that they are often deficient in pesticide loading when sown. When cereal seeds were pretreated with an adhesive formulation before the application of a powder treatment, the adherence of the powder was greatly improved. The vegetable oil emulsion used as pretreatments gave the greater improvement of adherence, without increasing the phytotoxic effect of gamma-BHC applied as the insecticide. Although the other adhesives stuck gamma-BHC powder to seeds, they all had some effect on germination.

9.21 (KHAN, N., FERHAT, S., BAIG, M. M. H.) & LORD, K. A. (1972) Volatilisation of gamma-BHC at tropical temperature. *Pakistan Journal of Scientific and Industrial Research* **15**, 3, 227–228.

Gamma-BHC emulsion was sprayed on rice plants and residues tested by gas chromatography. Results indicated rapid loss of insecticide from the plants as very little quantity was found on them after 3 hours. Volatilisation, therefore, appears to be the possible cause of loss. This suspicion was confirmed when small quantities of gamma-BHC, in n-hexane, was applied onto glass cover-slips, washed and assayed and found that evaporation rate was dependent upon surface area. BHC emulsion is, therefore, unlikely to give prolonged protection to plants.

9.22 (MACHIN, A. F., QUICK, M. P., ROGERS, H.) & JANES, N. F. (1972) An isomer of hydroxydiazinon formed by metabolism in sheep. *Bulletin of Environmental Contamination and Toxicology* **7**, 270–272.

The detection and characterisation of a new metabolite of diazinon is reported. Its structure, proved by the n.m.r., i.r. and mass spectra of the isolated metabolite, is diethyl 6-hydroxymethyl-2-isopropyl-4-pyrimidinyl phosphorothionate.

9.23 MCINTOSH, A. H. (1973) Glasshouse tests of chemicals for control of potato common scab. *Annals of Applied Biology* **73**, 189–196.

Quintozene is the only chemical used successfully in practice to control soil-borne *Streptomyces scabies*, the cause of potato common scab. However it may be carcinogenic, and the aim of this work was to find a substitute for it.

About 100 chemicals, most of which had known fungitoxic action or were related to such chemicals, were tested in the glasshouse by growing potato plants in soil with which the chemicals had been mixed, usually at 50 ppm. Many of the chemicals failed to decrease the incidence of scab, or decreased the yield of tubers, or both. The most effective chemical was captafol, which was as effective as quintozene and, unlike quintozene, did not decrease yield. Captan and folpet, which are very closely related to captafol, were ineffective.

9.24 MUDD, A. & (CORBET, S. A.) (1973) Mandibular gland secretion of larvae of the stored products pests *Anagasta kuehniella, Ephestia cautella, Plodia interpunctella* and *Ephestia elutella*. *Entomologia Experimentalis et Applicata* **16**, 291–293.

The mandibular glands of larvae of the flour moth *Anagasta kuehniella* (Zeller) contain a secretion which regulates the density of the larval population. A component of this secretion,

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which elicited strong oviposition responses from the ichneumonid parasite *Venturia canescens* (Grav), was isolated and shown to have the molecular constitution $C_{24}H_{40}O_4$. The same compound, which appears to be a novel natural product, was shown to be present in the mandibular gland of three related lepidopteran pests *Ephestia cautella* (Wlk.), *Ephestia elutella* (Hübn.) and *Plodia interpunctella* (Hübn.), suggesting that the pheromone mediated population regulation mechanism demonstrated for *A. kuehniella* may also operate in other Lepidoptera.

9.25 NEEDHAM, P. H. & STEVENSON, J. H. (1973) The toxicity to foraging honeybees, *Apis mellifera*, of endosulfan, malathion and azinophos-methyl applied to flowering oil seed rape, *Brassica napus*. *Annals of Applied Biology* **75**, 235–240.

Wettable powder and emulsifiable concentrate formulations of endosulfan and azinphos-methyl and an emulsifiable concentrate of malathion were sprayed on oil seed rape in full flower to assess their relative toxicities to foraging honeybees. Endosulfan was very much safer to honeybees than the two organophosphate insecticides, but there was little difference between the two types of formulation.

9.26 (PEREGRINE, D. J.), MUDD, A. & (CHERRETT, J. M.) (1974) Anatomy and preliminary chemical analysis of the post-pharyngeal glands of the leaf cutting ant *Acromyrmex octospinosus* Reich. (Hym. Formicidae). *Insectes Sociaux* **20**, 355–363.

The post-pharyngeal glands of *Acromyrmex octospinosus* are a pair of glove-shaped glands lying over the brain and opening into the pharynx. A single layer of cells, lined on the inside with cuticle, make up the wall of the gland. There is a complex system of muscles where the gland joins the gut, which probably control the release of the gland contents into the gut.

The lumen of the gland contains a yellow oil which is mostly a mixture of about 10 triglycerides (mainly a dioleoyl palmitin). Minor components include free fatty acids (mainly palmitic acid) and sterols (almost exclusively ergosterol), showing that at least some of the gland components are derived from dietary lipids.

The gland contents serve as a supplementary diet for the larvae.

9.27 PHILLIPS, F. T. (1974) Some aspects of volatilisation of organochlorine insecticides. Society of Chemical Industry Symposium on Factors Affecting the Distribution of Pesticides Throughout the Atmosphere. *Chemistry and Industry*, No. 5 (March) 193–197.

The rate of loss of an insecticide is governed by its saturation vapour concentration and the rate its vapour diffuses through the still air layers (about 2 mm thick) next to the treated surface.

Factors which influence these parameters to varying degrees include: the vapour pressure of insecticide, temperature, wind speed, humidity, crystal size, type of formulation, and type of substrate.

The kinetics of evaporation of insecticides from surfaces may be described by one form or other of exponential curves (single, double, or logistic) and the shapes of these curves show that very high percentages of the insecticide may be lost by volatilisation soon after application. A slow release formulation such as that provided by microencapsulation of the insecticide is shown to at least halve these losses.

9.28 PHILLIPS, F. T. & KAVADIA, V. S. (1973) The movement of dieldrin in young cotton plants. In: *The use of isotopes and radiation in agriculture and animal husbandry research. International Symposium on the Use of Isotopes and Radiation in Agriculture.* (Delhi, December 1971.)

Dieldrin (HEOD) was taken up from aqueous suspensions via the roots of young cotton plants and transported to the stems and leaves. The uptake was probably controlled by the transpiration rate.

Considerable localised movement of dieldrin occurred from spray droplets on the upper surface of cotton leaves. Lateral movement along the upper surfaces was rapid, at least one-fifth of the applied HEOD moving over distances of 8 mm within four days, but vertical penetration

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of HEOD from the upper to lower surfaces of leaves took several weeks and was apparently dependent on the thickness of the cuticular layers of the leaves.

9.29 PHILLIPS, F. T., SETHI, G. R. & KAVADIA, V. S. (1974) Quick estimation of dieldrin in fresh cotton-leaf samples. *Pesticide Science* **4**, 811–816.

Hexane was the most convenient extraction solvent. Consistent recoveries of 80% HEOD were obtained after cold grinding with 10 ml hexane/g of leaf for 5 min. After filtering, solutions did not require a 'clean-up' before g.l.c. analysis, provided they were not concentrated further. Radioactive HEOD in such extracts could be directly counted with a simple scintillation apparatus if pre-treated with acidified potassium permanganate solution to eliminate the colour-quenching effect and stored in the dark for 24 h to allow phosphorescence from some leaf materials to decay.

Extractions using other solvents would need a 'clean-up' procedure before g.l.c. analysis, but radioactive HEOD in hexane-propan-2-ol extracts could be quickly estimated by simple scintillation counting after decolorisation with sodium hypochlorite and storage in the dark for 24 h

9.30 SAWICKI, R. M. (1974) Genetics of resistance of a dimethoate-selected strain of houseflies (*Musca domestica* L.) to several insecticides and methylenedioxyphenyl synergists. *Journal of Agriculture and Food Chemistry* **22** No. 1.

At least five genes control or modify resistance to insecticides or synergists in the dimethoate-selected Danish strain $49r_2b$ of housefly (*Musca domestica* L.). On chromosome 2, gene *M* close to the marker *ar* controls resistance to malathion, malaoxon, and tetrachlorvinphos, gene *D*, about 20 map units from *ar*, controls resistance against dimethoate and several other organophosphorus insecticides, and gene *Pb*, close to gene *D*, controls resistance to methylenedioxyphenyl synergists and synergised pyrethrum but not pyrethrum alone. The mechanism of resistance controlled by gene *D* is sesamex suppressible and confers stronger resistance against the phosphates than the corresponding phosphorothioates. On chromosome 5 gene *R5* controls another sesamex-suppressible mechanism of resistance to dimethoate, and on chromosome 3 gene *Pen* controls the mechanism, delaying entry of insecticides into houseflies, which intensifies the resistance conferred by the other genes. Retention of parathion resistance following the switchover of control from parathion to dimethoate was probably caused by the progressive disappearance of gene *a*, which conferred resistance to parathion but not dimethoate, and its replacement by gene *D*, which confers resistance to both dimethoate and parathion.

9.31 SAWICKI, R. M. (1973) Resynthesis of multiple resistance to organophosphorus insecticides from strains with factors of resistance isolated from the SKA strain of house flies. *Pesticide Science* **4**, 171–180.

Individual factors of resistance to insecticides attributable to chromosomes II, III and V of the SKA strain of houseflies (*Musca domestica* L) were combined in pairs to determine how their presence affects resistance. The re-synthesised strains with resistance factors on chromosomes II and V, and on chromosomes III and V, were tested with several organophosphorus insecticides and DDT. The penetration delaying mechanism *Pen* on chromosome III, which alone gives little or no resistance, slightly increased the resistance of flies with the microsomal detoxifying factor *Ses* on chromosome V to diazinon and malaoxon-ethyl (c. $\times 1{\cdot}5$), but was more effective in increasing resistance to DDT ($\times 6$). There was no effect on the response to other insecticides tested. The combined effect of the mechanisms of resistance on chromosome II (glutathione *S*-ethyl transferase and phosphatase) and on chromosome V (microsomal detoxication) approximated to the product of the resistance conferred by each of these mechanisms singly, suggesting that the mechanisms of resistance on the two chromosomes act independently. Therefore, most of the strong resistance to organophosphorus insecticides in the SKA strain results from the interaction between delayed penetration (chromosome III) and the factors of resistance on chromosome II, and the independent action of the resistance factors on chromosomes II and V.

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9.32 SCOTT, G. C. & GREENWAY, A. R. (1973) Effects of cereal extracts on attack on wheat by wheat bulb fly, *Leptohylemyia coarctata*. *Entomologia Experimentalis et Applicata* **16**, 554–556.

Since chemicals present in or exuding from wheat and oat plants may assist larvae of wheat bulb fly either to locate host plants or to avoid non-hosts, the effects of applications of wheat or oat extracts on attack by larvae on wheat growing in seed boxes in a glasshouse were examined.

The progress of attack was followed by counting and marking damaged shoots each week. The initial damage to shoots was similar for each treatment. Two weeks later, however, when larvae were leaving their first sites of infestation and attacking further shoots, there was a significant decrease in total numbers of attacked shoots in boxes treated with oat extract compared with the wheat extract or water (controls) treatments.

9.33 TISDALE, M. J. & LORD, K. A. (1973) Uptake and distribution of thiabendazole by seed potatoes. *Pesticide Science* **4**, 121–130.

The uptake of thiabendazole into potato seed tubers (cultivar King Edward) was determined by the method of application, more being taken up from solutions and suspensions than from dusts. Penetration and uptake were greatest with solutions at pH 3, and less at higher or lower pHs. The addition of inorganic salts (KCl, $CaCl_2$) had no effect. Treatment of tubers with weak solutions of mineral acid increased uptake of thiabendazole. There was little movement and no metabolism of the chemical when potatoes were stored for three months.

Entomology Department

BOOK

10.1 LEWIS, T. (1973) *Thrips, their biology, ecology and economic importance*. London and New York: Academic Press, 349 pp., 16 pl.

THESIS

10.2 SHERLOCK, P. L. (1973) *Tipula paludosa* Mg. (Diptera : Tipulidae). A survey of its pathogens and a study of the gregarines of the Family Diplocystidae. Ph.D. Thesis. University of Newcastle-upon-Tyne.

GENERAL PAPERS

10.3 BAILEY, L. (1973) Viruses and Hymenoptera. In: *Viruses and invertebrates*. Ed. A. J. Gibbs. Amsterdam and London: North-Holland, Chapter 22, pp. 442–454.

10.4 BAILEY, L. (1973) Control of invertebrates by viruses. In: *Viruses and invertebrates*. Ed. A. J. Gibbs. Amsterdam and London: North-Holland, Chapter 29, pp. 533–553.

10.5 BOWDEN, J. (1973) Migration of pests in the tropics. *Proceedings XXV International Symposium on Crop Protection. Mededelingen Fakulteit Landbouwwetenschappen, Gent* **38**, 785–796.

10.6 BUTLER, C. G. (1973) The queen and the 'spirit of the hive'. Presidential Address to the Royal Entomological Society of London. *Proceedings of the Royal Entomological Society of London* **37**, 59–65.

10.7 (CHERRETT, J. M.) & LEWIS, T. (1974) Improved control of leaf-cutting ants by exploiting their natural behaviour. *British Ecological Society Symposium No. 13*, 130–146.

10.8 EDWARDS, C. A. (1973) Changes in populations of soil animals due to pesticides. *Sylva* **52**, 12–15.

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10.9 EDWARDS, C. A. (1974) Biological aspects of the degradation and behaviour of pesticides in soil. *Proceedings of the 7th British Insecticides and Fungicides Conference* **3**, 811–824.

10.10 EDWARDS, C. A. (1974) Factors affecting the persistence of pesticides in the soil. *Chemistry and Industry* No. 5, March 1974, 190–193.

10.11 EDWARDS, C. A. (1974) Macroarthropods. In: *Biology of plant litter decomposition.* Ed. G. F. Pugh & C. H. Dickinson. London and New York: Academic Press, Chapter 16, pp. 533–554.

10.12 EDWARDS, C. A. (1973) Some influences of pesticides on the soil fauna. *Proceedings of the XXXIV Winter Congress of the Institut International de Recherches Betteraviéres* **6**, 87–93.

10.13 FREE, J. B. (1973) Bees and other insect pollinators of crops. *Apiacta* **8**, 19–27.

10.14 JOHNSON, C. G. & BOWDEN, J. (1974) Problems related to the transoceanic transport of insects, especially between the Amazon and Congo areas. In: *Tropical forest ecosystems in Africa and South America: a comparative review.* Ed. B. J. Meggers, E. S. Ayensa & D. Duckworth. Washington: Smithsonian Institution Press, pp. 207–222.

10.15 LEWIS, T. (1973) Agriculturalists of the insect world. *Spectrum* **109**, 7–8.

10.16 LOFTY, J. R. (1974) Oligochaetes. In: *Biology of plant litter decomposition.* Ed. G. F. Pugh & C. H. Dickinson. London and New York: Academic Press. Chapter 14, pp. 467–488.

10.17 (PHILLIPS, F. T.) & LEWIS, T. (1974) Current trends in the development of baits against leaf-cutting ants. *PANS* **19**, 483–487.

10.18 TAYLOR, L. R. (1973) Monitor surveying for migrant insect pests. *Outlook on Agriculture* **7**, 109–116.

10.19 TURNER, R. H. & EDWARDS, C. A. (1974) Scanning electron microscope studies of Symphyla. *Symposia of the Zoological Society of London* **32**, 135–142.

PAPERS IN ROTHAMSTED REPORT, PART 2

10.20 TAYLOR, L. R. (1974) Monitoring change in the distribution and abundance of insects. *Rothamsted Experimental Station. Report for 1973*, Part 2, 202–239.

Effective control of crop pests that are erratic in appearance requires an understanding of spatial population dynamics not yet available. This paper describes an attempt to measure the whole populations of moths and aphids over Great Britain and the daily changes in their distributions, the techniques used, and what must be known of such populations before the necessary measurements can be made effectively. Examples are given of the annual distributions of moths; daily, monthly and annual distributions of aphids; and the diversity of moth populations. Sequential differences of distribution maps show changes in populations and sums show the stable background to which some species constantly revert. Population diversity is shown to be related to land use.

10.21 TAYLOR, L. R. & FRENCH, R. A. (1974) Rothamsted Insect Survey. *Rothamsted Experimental Station. Report for 1973*, Part 2, 240–269.

Tables list the four-week total catches of 32 aphid spp., or species groups, from 18 suction traps sited in Britain, Denmark and Holland for the period 26 March to 4 November 1973; and the

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annual total of 31 spp. of Lepidoptera of economic importance from light traps at 72 sites in 1971 and 88 sites in 1972.

RESEARCH PAPERS

10.22 BAILEY, L. (1972) The preservation of infective microsporidan spores. *Journal of Invertebrate Pathology* **20**, 252–254.

The median infective doses of spores of *Nosema apis* preserved at −20°C within the tissues of freshly killed infected bees were 21, 41 and 157 after 0, 12 and 24 months, respectively. The LD50 of spores in lyophilised tissue was 35 after one month. Probably only one spore can infect a bee.

10.23 BAILEY, L. & (SCOTT, H. A.) (1973) The pathogenicity of Nodamura virus for insects. *Nature, London* **241**, 545.

Nodamura virus, isolated originally from mosquitoes in Japan and found lethal for suckling mice, killed adult honeybees and larvae of greater wax-moths. The virus that multiplied in bees or wax-moths was serologically identical to that from mosquitoes or mice.

10.24 (NEWMAN, J. F. E., BROWN, F.), BAILEY, L. & (GIBBS, A. J.) (1973) Some physico-chemical properties of two honey-bee picornaviruses. *Journal of General Virology* **19**, 405–409.

The base compositions of acute bee-paralysis and sacbrood viruses were similar. However, acute bee-paralysis virus particles were morphologically stable at pH 3·0 and their buoyant density of 1·34 g/cm³ increased above pH 7·0, whereas sacbrood virus particles were unstable below pH 5·0 and their buoyant density of 1·33 g/cm³ was stable. In all these respects the viruses differed from mammalian picornaviruses.

10.25 BOWDEN, J. (1973) The significance of moonlight in photoperiodic responses of insects. *Bulletin of Entomological Research* **62**, 605–612.

In the tropics, the amount and pattern of distribution of moonlight at and just after full moon produces alternating periods of continuous illumination and darkness which could provide photoperiodic cues for insects. Examples of possible photoperiodic effects induced by moonlight include the flight activity and oviposition patterns of females of *Heliothis zea* (Boddie) and *Diatraea saccharalis* (F.) and crepuscular activity of mosquitoes. It is suggested that photo-periodic responses to moonlight could form the basis for a simple method of predicting such events.

10.26 BOWDEN, J. (1973) The influence of moonlight on catches of insects in light-traps in Africa. Part I. The moon and moonlight. *Bulletin of Entomological Research* **63**, 113–128.

An account is presented of the distribution and amounts of moonlight in latitudes near the equator. This includes a Table of the amount of moonlight for each hour of the night throughout a standard lunar cycle, applicable to any locality between 10°N and 10°S, and a Table of standard groups of moonphase which can be used at any locality irrespective of latitude. A method is described which enables light-trap catch records to be arranged for analysis directly against moon phase.

10.27 BOWDEN, J. & CHURCH, B. M. (1973) The influence of moonlight on catches of insects in light-traps in Africa. Part II. The effect of moon phase on light-trap catches. *Bulletin of Entomological Research* **63**, 129–142.

Nightly light-trap catches of insects, covering periods of two to five years, from two sites in Africa within 10° of the equator are examined in relation to the regular changes in night illumination of the lunar cycle. For several species average log catches at different phases of the moon are almost linearly related to (log) night illumination, catches of some species increasing and of others decreasing with moonlight. Analysis of whole-night catches gives some evidence on the

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pattern of activity through the night and evidence on how night illumination affects catch, and on the times of night when illumination has most effect, is consistent for the two sites and for different years. However, any adjustment of nightly catch to those expected under standard conditions of illumination can only be approximate. Although most of the differences between catches at different moon phases are accounted for by night illumination, many factors influence catch on any particular night, and moonlight is a major factor only for certain species. An hypothesis about how a light-trap may affect insect behaviour allows changes in catch of some species over the lunar cycle to be explained by the influence of background illumination on trap effectiveness.

10.28 BOWDEN, J. & GIBBS, D. G. (1973) Light-trap and suction-trap catches of insects in the northern Gezira, Sudan, in the season of southward movement of the Inter-Tropical Front. *Bulletin of Entomological Research* **62**, 571–596.

Catches in light-traps adjoining cotton were obtained at the time of seasonal southward movement of the Inter-Tropical Front (ITF) in October and during most of the following two months. Suction-trap catches at three heights up to 50 ft were obtained for short periods in October and November, and some aircraft catches were also available. Suction-trap catches of grass-feeding Homoptera suggest that displacement of these insects was associated with changes in wind direction marking movement of the ITF in October. It seems likely that proximity of the Front at or soon after the time of a brief period of crepuscular activity stimulates insects to take flight and rise to 50 ft or more so that they are displaced. In many taxa, light-trap catches showed a regular pattern of increase, with only slight nightly fluctuations from a logarithmic trend, following full moon. The pattern of change after full moon, shown most clearly in taxa with source populations close to the trap, was related to the moon's influence on the range of trap effectiveness. Various qualitative variations suggest that, in addition, aspects of behaviour or development may have adaptive relationships to the lunar cycle.

10.29 BUTLER, C. G., CALLOW, R. K., KOSTER, C. G. & SIMPSON, J. (1973) Perception of queens by workers in colonies of *Apis mellifera* L. in the hive. *Journal of Apicultural Research* **12**, 159–166.

Workers gathered on cages containing mated, laying queens that were placed above normal, queenright colonies. Fewer workers gathered on a cage when they could not touch the caged queen, or when she was dead, or when her mandibular glands had been removed. The number of workers on the cage was correlated with the amount of 9-oxodecenoic acid in the queens' heads. Workers gathered on cages containing only 9-oxodecenoic acid on filter-paper that the bees could not touch. 'Court' formation round a free queen was not diminished by removing her mandibular glands. The heads of queens whose mandibular glands had been removed contained traces of 9-oxodecenoic acid. No hitherto unknown substance affecting worker bees' behaviour was detected in the queen's head. No sounds likely to be specifically communicative were heard from the queen or from workers that formed a 'court' round her. Workers did not move from afar to form a 'court' round a queen. It is concluded that in an undisturbed colony with a mated, laying queen there is no attraction of workers towards the queen except over very short distances.

10.30 DEAN, G. J. W. (1973) Bionomics of aphids reared on cereals and some Gramineae. *Annals of Applied Biology* **73**, 127–135.

In controlled temperature, light and relative humidity, *Metopolophium dirhodum* and *Sitobion avenae* multipled more on young Proctor barley than on Blenda oats, and less on Cappelle wheat. *Rhopalosiphum padi* increased in number fastest on barley and slowest on oats. More survived, and generation lengths seemed shorter, on barley for *M. dirhodum* and *S. avenae* and on wheat for *R. padi*. Tests with young cereals outdoors generally agreed with those in controlled conditions. On mature plants, there were more *M. dirhodum* on barley, more *R. padi* on wheat and more *S. avenae* on oats than on the other cereals. Given a free choice in large cages outdoors, most aphids were found on barley. When allowed to choose between grasses, more *M. dirhodum* were on *Dactylis glomerata*, *Poa pratensis* and *Festuca pratensis*, more *R. padi* on *Lolium perenne* and *F. pratensis*, and more *S. avenae* on *D. glomerata* and *L. perenne*. Most

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aphids of all species combined were on *F. pratensis*, *Lolium* and *Phleum*, and fewest on *Festuca rubra* and *Holcus mollis*.

10.31 DEAN, G. J. W. (1973) Aphid colonisation of spring cereals. *Annals of Applied Biology* **75**, 183–193.

In 1970–71, *Metopolophium dirhodum*, *Rhopalosiphum padi* and *Sitobion avenae* were the commonest alatae trapped from April/May to August, with most in July and early August. The first alatae appeared in the Rothamsted survey suction trap 0–34 days before aphids were found on the cereals, but during May and June no relationship was found between the numbers trapped and the number on the crop. Most species occurred first near the sheltered edge of the crop, but *M. dirhodum* was widespread over the field. Most infestations were quickly dispersed by the movements of older morphs; adults only stayed in one place for about two days. Alate *M. dirhodum* moved more often than apterae, but both morphs of *S. avenae* moved equally often and more frequently between larvipositions than did those of *M. dirhodum*. Apterae deposited more nymphs in a 'group' than alatae, and *M. dirhodum* deposited more than *S. avenae*. Few 'groups' persisted for more than a week. Although *M. dirhodum* occupied the crop area faster than *S. avenae*, all 0·3 m lengths of row sampled being infested within two to five weeks of their first appearance, most or all of the tillers were colonised only in late July 1970.

10.32 DEAN, G. J. W. (1973) Distribution of aphids in spring cereals. *Journal of Applied Ecology* **10**, 447–462.

Aphids, mainly *Metopolophium dirhodum* with fewer *Sitobion avenae*, invading cereals in May were scarce until after mid-June, most in mid-July, and gone after early August. Aphid densities were greater in 1970 than in 1971, but they probably affected grain yield for only about a week in July 1970. In June, *S. avenae* occurred mainly around the crop edge, while *Metopolophium dirhodum* was widespread. In July, *S. avenae* infested the whole crop, with most in sheltered areas, whereas *M. dirhodum* was common everywhere. Both species occupied the leaves until after heading, when most *S. avenae* invaded the ears and most *M. dirhodum* remained on the leaves.

In 1970, *M. dirhodum* 'groups' were larger (max. 74) than *S. avenae* 'groups' (max. 42), but in 1971, they were similar and smaller (max. 38 *S. avenae*). *S. avenae* occurred singly more often than *M. dirhodum*. In 1970, the largest 'groups' of *M. dirhodum* appeared a week before, and of *S. avenae* up to five weeks before, the maximum numbers of 'groups'/0·3 m row, whereas they coincided in 1971. Mean numbers of 'groups' and aphids/0·3 m row were related, but 'group' size was independent of population size.

10.33 DEAN, G. J. W. & WILDING, N. (1973) Infection of cereal aphids by the fungus *Entomophthora*. *Annals of Applied Biology* **74**, 133–138.

Three species of *Entomophthora* killed many *Metopolophium dirhodum*, *M. festucae* and *Sitobion avenae* on wheat at Harpenden, Hertfordshire, in 1971. Rainfall was low and aphid numbers were small in May and there was no *Entomophthora* infection. *E. planchoniana* first infected *M. dirhodum* early in June and the percentage of each aphid species infected increased during and after heavier rain in the first two weeks of June. *M. dirhodum* and *S. avenae* were most often infected by *E. planchoniana*, and the less common *M. festucae* mostly by *E. aphidis* and *E. thaxteriana*. Relative frequencies of *E. aphidis* and *E. thaxteriana* were largest before, and of *E. planchoniana* after, mid-July. The largest percentages infected were 53% of *M. dirhodum* and 30% of *S. avenae* during the second half of July, and 60% of *M. festucae* in late June. The percentages of old nymphs and apterous adults that were infected were similar and only about half those of infected alatae.

10.34 EDWARDS, C. A. & JEFFS, K. (1973) The rate of uptake of DDT from soil by earthworms. *Nature, London* **247**, 157–158.

Lumbricus terrestris placed in soil containing approximately 1 ppm of DDT accumulated about 4 ppm of the insecticide, taking two to four months to reach equilibrium. More than half the residues in worms after six months were DDE. Worms containing 7 ppm of DDT residues,

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most of which was DDE, when placed in clean soil excreted all the DDT in less than a month, but about 1·5 ppm of the DDE was retained in their tissues for more than two months.

10.35 EDWARDS, C. A. (1974) Some effects of insecticides on myriapod populations. *Symposia of the Zoological Society of London* **32**, 626–636.

The effects of aldrin, DDT, chlorfenvinphos, diazinon, disulfoton, parathion and phorate on populations of Pauropoda, Symphyla, Diplopoda and Chilopoda, were studied in four field experiments. Plots 3 m square were treated and the insecticide cultivated into the soil. Samples were taken at monthly or two-monthly intervals. Pauropoda were extremely susceptible to all the insecticides, Symphyla and Chilopoda less so and Diplopoda were little affected by any insecticide.

10.36 FREE, J. B. & WILLIAMS, I. H. (1973) The foraging behaviour of honeybees (*Apis mellifera* L.) on Brussels sprout (*Brassica oleracea* L.) *Journal of Applied Ecology* **10**, 489–499.

When foraging on Brussels sprout cultivars with small flowers, nectar-gathering honeybees preferred to visit the inner nectaries which they approached through the mouths of the flowers. More nectar-gatherers alighted on the outside of flowers of cultivars with deeper corolla tubes and larger floral parts, and inserted their tongues between the perianth segments to reach the outer nectaries, probably because they could not reach the inner ones. Bees soon learned to 'rob' flowers and the ease with which they did so increased as a flower became older and its perianth segments spread apart. Most bees visiting some cultivars were 'robbers', particularly at the later stages of flowering. However, some cultivars with small flowers were never 'robbed'. Flowers were less likely to be pollinated by robber bees than by bees that entered them. Robbing can be discouraged by selecting cultivars the inner nectaries of which can easily be reached by bees, and also by increasing the proportion of pollen- to nectar-gatherers visiting the crop. In cages, bees did not discriminate between different cultivars, but in an open plot of ten cultivars different bees preferred different cultivars, some showing considerable constancy to the one they chose. Nectar availability may sometimes influence the choice of cultivars. The implications of these findings to the production of hybrid seed are considered.

10.37 FREE, J. B. & WILLIAMS, I. H. (1974) The pollination of hybrid kale (*Brassica oleracea* L.). *Journal of Agricultural Science* **81**, 557–559.

Honeybees were able to distinguish between the flowers of two different cultivars of kale grown to produce hybrid seed, most foraging only on one or other of them.

10.38 GIBSON, R. W. (1974) The induction of top-roll symptoms on potato plants by the aphid *Macrosiphum euphorbiae*. *Annals of Applied Biology* **76**, 19–26.

In the field, caged King Edward and Majestic potato plants infested with *Macrosiphum euphorbiae* developed top-roll symptoms, the proportion of affected plants increasing with the size and persistence of the aphid population. Yield of tubers from plots in which 90% of the plants had top-roll symptoms was 40% less than that from control plots; yield of saleable ware was even less. Foliage produced after the aphids had been killed was symptomless even when it arose from the axil of an affected leaf. Caged field plants treated with phorate granules to prevent aphid attack did not develop top-roll. Prolonged infestation of Pentland Crown, Majestic and King Edward plants by *M. euphorbiae* in a glasshouse induced rolling of the upper leaves similar to top-roll of field plants. Experimental results suggest that rolling was directly attributable to heavy attack by *M. euphorbiae*, not to an aphid-transmitted pathogen.

10.39 KEMPTON, R. A., BARDNER, R., FLETCHER, K. E., JONES, M. G. & MASKELL, F. E. (1974) Fluctuations in wheat bulb fly egg populations in Eastern England. *Annals of Applied Biology* **77**, 102–107.

Fluctuations on mean egg densities from field samples in the ADAS Eastern Region for the past 20 years are analysed to determine what factors have important effects on egg density. In both light and heavy soils over 70% of the variation in egg density between years could be linked to

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variation of three factors: availability of egg-laying sites; autumn rainfall, affecting date of sowing of winter wheat; the January soil temperature, affecting date of hatching of the eggs.

10.40 KEMPTON, R. A. & TAYLOR, L. R. (1974) Log-series and log-normal parameters as diversity discriminants for the Lepidoptera. *Journal of Animal Ecology* **43**, 381–399.

The relative abundance of species of moths in four years' light trap samples from eighteen sites were fitted to log-series and log-normal frequency distributions. Samples from stable environments were best fitted by the log-series. Increased skewness in changing environments better fitted the log-normal. The fit of the distributions was not a product of the light trap; suction traps gave similar distributions but with different parameters. The log-series index α was a highly efficient site discriminant and robust, yielding reasonable values with only moderate distribution fit. Neither S^* not σ, from the log-normal, were able to discriminate between sites. $S^*/3\sigma$ gives values closely similar to α, but was more sensitive to fit in both tails of the distribution. α was independent of sample size.

10.41 LEWIS, T. & PHILLIPS, F. T. (1973) Aerial baiting to control leaf-cutting ants (Formicidae, Attini) in Trinidad. I. The bait, its production, and the effect of weathering on attractiveness and persistence of toxicants. *Bulletin of Entomological Research* **63**, 263–274.

A technique is described for the preparation of large quantities (up to 1100 kg) of plain and waterproofed leaf-cutting ant bait from dried citrus meal, soyabean oil and aldrin. Small amounts (500 g) were weathered in sun and shade during wet and dry periods in Trinidad and the acceptability of the bait to ants (*Acromyrmex octospinosus* (Reich) and *Atta cephalotes* (L.)) and the persistence of toxicants in it were assessed in laboratory tests. Methyltrichlorosilane was the most effective of three waterproofing agents tested. In the wet season, waterproofed bait remained acceptable to ants for at least 30 days whereas plain bait deteriorated in less than four days; in the dry season waterproofed bait was only marginally more attractive. In the wet season, *Acromyrmex* strongly preferred weathered, waterproofed bait to fresh leaves, whereas *Atta* slightly preferred leaves to bait. In the dry season, *Acromyrmex* showed little preference between bait and leaves, whereas *Atta* much preferred bait. Over the period that the bait remained attractive to the ants it retained between one-third and two-thirds of the original aldrin in the form of aldrin and dieldrin.

10.42 LEWIS, T. (1973) Aerial baiting to control leaf-cutting ants (Formicidae, Attini) in Trinidad. II. Field application, nest mortality and the effect on other animals. *Bulletin of Entomological Research* **63**, 275–289.

Aircraft were used to apply a bait containing aldrin, soyabean oil and citrus meal against leaf-cutting ants (*Acromyrmex octospinosus* (Reich) and *Atta cephalotes* (L.)) in Trinidad. The distribution patterns of bait applied by different aircraft were measured. Plain bait applied at 2·2 kg/ha to an uncultivated island in the dry season destroyed 91% of nests of *Acromyrmex* and waterproofed bait applied in the wet season to cultivated land on the mainland destroyed 85%. Small nests of *Atta* were also destroyed by this treatment but large nests in forests required much heavier doses applied to the nests themselves. Lizards and crabs living in the baited areas were contaminated with aldrin but there was no evidence to show that they were harmed.

10.43 LEWIS, T. & (NORTON, G. A.) (1973) Aerial baiting to control leaf-cutting ants (Formicidae, Attini) in Trinidad. III. Economic implications. *Bulletin of Entomological Research* **63**, 290–304.

The losses caused by leaf-cutting ants (*Acromyrmex octospinosus* (Reich) and *Atta cephalotes* (L.)) to citrus and cocoa crops in Trinidad were assessed at about $40 000 TT per annum in each of these crops. Losses to other crops were unassessable on a national scale but often important to individual farmers. Aerial baiting, using a locally produced bait of aldrin, soyabean oil and citrus meal, would be at least as, and probably more, effective than current on-farm control methods. The cost was $6·18/ha, approximately four times cheaper than current methods and twice as cheap as searching for nests and applying the same bait to them by hand. Hand-baiting

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with the local bait would be almost twice as cheap as using the imported alternative available. At the dosages and frequency of application recommended (2·2 kg of bait containing 0·4% technical aldrin/ha/annum) the total amount of organochlorine insecticide currently used against leaf-cutting ants in Trinidad would decrease between two- and ten-fold, depending on the area treated. Serious long term residual effects are most unlikely to develop, and if bait were applied carefully no harmful effects to man or stock would occur. Farms larger than four hectares would benefit proportionately more than smaller farms, unless charges were manipulated. Fewer men would be needed to control ants than at present. Losses to traders caused by a decrease in the sales of alternative insecticides would be trivial. A national dry-season baiting scheme would utilise more fully aircraft already available in Trinidad, and would help export crops and the production of home-grown foods.

10.44 LEWIS, T., (POLLARD, G. V.) & DIBLEY, G. C. (1974) Rhythmic foraging in the leaf-cutting ant *Atta cephalotes* (L.) (Hym.). *Journal of Animal Ecology* **43**, 129–141.

Individual aspects of foraging behaviour are described as a background to a study of collective aspects, especially the diel and long-term rhythms occurring in forest and cacao fields in Trinidad.

The larger the nest the further do ants travel to cut leaves, up to a maximum direct distance of about 250 m. In fine weather, on crowded trails, outgoing unladen and ingoing laden ants travel at about 1 m/minute, take 2–3 minutes to cut a leaf fragment, and on returning to the nest stay inside 10–30 minutes before departing on another foraging trip. Typical foraging trips last 3–5 hours. Only about 6% of ants in each nest were foragers, and changes in the number of leaf fragments carried into the nest during a foraging period depended on the total number of ants foraging rather than on changes in their spread of movement. On each trail, foraging persisted for about 7·5 hours in daylight or 12 hours in darkness. Diel rhythms of activity often differed between nests and even between trails of the same nest. Ants foraged mostly by night and once a particular diel rhythm was established it persisted for several weeks. Neither photoperiodism, lunar cycles nor any other widespread component of the physical environment adequately accounted for the long-term or diel rhythms observed.

10.45 LEWIS, T., (POLLARD, G. V.) & DIBLEY, G. C. (1974) Microenvironmental factors affecting diel patterns of foraging in the leaf-cutting ant *Atta cephalotes* (L.) (Hym.). *Journal of Animal Ecology* **43**, 143–153.

A range of microweather factors including trail and nest internal temperatures, relative light intensity, relative humidity of the air, and atmospheric pressure, were measured each day when *Atta cephalotes* (L.) started foraging. None of these factors, nor temperature differentials between the interior and exterior of nests, nor changing trail temperatures, stimulated foraging or accounted for the changes in the total number of fragments collected daily by ants on a single trail. Rain delayed the start of foraging and caused ants outside the nest to return to it or shelter. A biological reason why ants that usually forage by night sometimes change to foraging by daylight is suggested.

10.46 MACAULAY, E. D. M. (1973) Tocopherol: Egg production and migration by *Plusia gamma* L. *Entomologia Experimentalis et Applicata* **16**, 48–52.

Honey or sucrose solutions, with or without tocopherol acetate, were fed to newly emerged female *P. gamma*. Eggs were matured at equal speeds on all diets. The differences between these and some previously published findings by other workers may be caused by differences in larval diets. The results are discussed in relation to migration.

10.47 MACAULAY, E. D. M. (1974) Lipid storage in the pre-imago and young adult *Plusia gamma* L. *Entomologia Experimentalis et Applicata* **17**, 53–60.

Changes in live weight, dry-weight and fat content of larvae, pupae and adults of *P. gamma* were assessed. Fat content increased during the larval life and decreased during the pupal stage. On emergence, adult moths contained about 11% fat per dry body weight. This amount is apparently sufficient to provide energy for flights of about 20 hours in the largest moths, and average moths flew for 3 hours without feeding.

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10.48 RYAN, M. F. (1973) The natural mortality of wheat-bulb fly eggs in bare fallow soils. *Journal of Applied Ecology* **10**, 869–874.

Survival of four populations of wheat-bulb fly eggs was studied. Few live eggs disappeared between the time of laying in July and August and hatching in February. Of 3000 eggs from soil samples, none were parasitised, 1% were diseased and 2–14% sterile. Carabid beetles were the most abundant potential predators present, but excluding them from plots did not affect egg mortality. *Bembidion lampros*, an important predator of cabbage-root fly eggs, formed only 1·9% of the total carabid catch. Only 21% of the carabids were present in the open field where wheat-bulb fly eggs are laid, the rest occurring round the edges of the field. Although three species of carabids forming 42% of the total catch destroy eggs, four species comprising 44% do not.

10.49 RYAN, M. F. (1973) The natural mortality of wheat bulb fly larvae. *Journal of Applied Ecology* **10**, 875–879.

Parasites, overcrowding, disease and predation had little effect on the mortality of wheat bulb fly larvae which seemed to depend on the supply of food for the younger larvae, which, when they were too abundant, left insufficient for the older ones. Evidence was obtained indicating that the mortality of both newly-hatched and older larvae was related to the number of shoots available per larva at the time of hatching.

10.50 SIMPSON, J. (1973) The influence of hive-space restriction on the tendency of honeybee colonies to rear queens. *Journal of Apicultural Research* **12**, 183–186.

Limiting the total hive-space of colonies to 37 litres, although it caused little, if any, restriction of space for brood or food, nevertheless resulted in an increase in the number of occupied queen cells, including sealed ones, in the colonies and increased the chance of the queens being reared to maturity.

10.51 TAYLOR, L. R. (1973) Insect migration, flight periodicity and the boundary layer. *Journal of Animal Ecology* **43**, 225–238.

Fifteen-point profiles of aerial density in relation to height up to 32 m were measured for 24 insect taxa. All profiles showed a discontinuity. This discontinuity occurred at a height of 30 cm for total insects, where mean wind speed matched mean flight speed. Flight behaviour above the discontinuity was much more consistent than below. Above the discontinuity, log density × log height regression coefficients conformed with expectation based on known behaviour, size, and upward atmospheric transport. The discontinuity thus agrees with expectation from the boundary layer hypothesis. The proportion of small insects above the boundary layer is significantly correlated with the diurnal flight periodicity of the taxon.

10.52 TAYLOR, L. R. & FRENCH, R. A. (1974) Effects of light trap design and illumination on samples of moths in an English woodland. *Bulletin of Entomological Research* **63**, 565–572.

Operated in sheltered woodland, the samples obtained by Rothamsted tungsten filament and Robinson mercury vapour light traps are best described by a spatial model different from that used in a site exposed to wind. Differences between the proportions of Noctuidae and Geometridae were accountable to differences in height of flight. The Rothamsted traps gave more consistent samples than the Robinson traps and averaged about one-quarter the number of moths.

10.53 TAYLOR, L. R., FRENCH, R. A. & MACAULAY, E. D. M. (1973) Low-altitude migration and diurnal flight periodicity; the importance of *Plusia gamma* L. (Lepidoptera : Plusiidae). *Journal of Animal Ecology* **42**, 751–760.

Plusia gamma migrates by day and night. In field observations made between 1933 and 1964, night-time flight is predominantly down-wind but day-time flight is not. This suggests that flight direction, *per se*, during migration is ecologically irrelevant. It is argued that migration in insects is largely the loss of social inhibitions and a resulting reversion to simple linear movement within the normal spatial reference frame of the species.

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10.54 WILDING, N. (1973) The survival of *Entomophthora* spp. in mummified aphids at different temperatures and humidities. *Journal of Invertebrate Pathology* **21**, 309–311.

Entomophthora aphidis survived for at least 32 weeks at 0°C and 20% or 50% RH, and *E. thaxteriana* for at least 16 weeks at 10°C and 20% or 50% RH, in mummified infected pea aphids, *Acyrthosiphon pisum*. The fungi produced infective conidia when the aphids were moistened. This probably explains the survival of *Entomophthora* spp. infecting aphids during short periods when the weather is unsuitable for conidial discharge and host infection.

10.55 WILDING, N. & LAUCKNER, F. B. (1974) *Entomophthora* infecting wheat bulb fly at Rothamsted, Hertfordshire, 1967–71. *Annals of Applied Biology* **76**, 161–170.

Entomophthora dipterigena, *E. hylemyiae* and, most commonly, *E. muscae* infected wheat bulb flies at Harpenden, Hertfordshire, between 1967 and 1971. The mean percentages of infected flies caught each year from 1967 to 1971 were 19, 0, 1, 29 and 16, respectively. These showed an increase with increasing host density. In 1970, two-thirds of the female flies were killed by *E. muscae* before they laid any eggs. Conidiophores developed in most flies infected with *E. muscae* during the two weeks after peak emergence of flies. Subsequently, resting spores developed in a progressively increasing proportion of infected flies. Resting spores developed in only six of the 130 infected males compared with 103 of 244 infected females in 1970 and 1971. The physiological age of infected flies probably determined whether conidophores or resting spores developed.

Molecular Structures Department

GENERAL PAPERS

11.1 TRUTER, M. R. (1973) Structures of organic complexes and alkali metal ions. *Structure and Bonding* **16**, 71–111.

11.2 TRUTER, M. R. (1973) Antibiotic ligands and model compounds. In: *Molecular structure by diffraction methods. Specialist Periodical Report. Chemical Society* **1**, 429–442.

RESEARCH PAPERS

11.3 BELFORD, R. C. E., FENTON, D. E. & TRUTER, M. R. (1974) Reactions of bis-(1,1,1,5,5,5-hexafluoropentane-2,4-dionato)-copper(II) with pyrazine and the crystal structures of the 1 : 1 and 2 : 1 complexes. *Journal of the Chemical Society* (*Dalton Transactions*), 17–24.

Reaction of $Cu(hfac)_2,H_2O$ [hfac = $(CF_3CO)_2.CH$] with equimolar amounts of pyrazine (pyz) in carbon tetrachloride gave the 1 : 1 complex (I) $Cu(hfac)_2(pyz)$. Recrystallisation from hot carbon tetrachloride gave (I) together with (II) $[Cu(hfac)_2]_2(pyz)$. A 1 : 2 mixture of reactants gave $Cu(hfac)_2(pyz)_2$.

Three-dimensional crystal structure analyses were carried out on (I) and (II). (I) is a linear-co-ordination polymer, having one molecule in a triclinic unit cell with space group $P\bar{1}$. The copper is six-co-ordinated and occupies a crystallographic centre of symmetry: the two chelating hfac rings give Cu–O 1·924 and 2·004(7) and the pyrazine rings give Cu–N 2·529(9) Å. Each pyrazine ring bridges two copper atoms related by the translation [0,1,1].

The 2 : 1 complex (II) is monoclinic, with two molecules in a unit cell of space group $P2_1/c$. The centre of the pyrazine ring is on a crystallographic centre of symmetry and the five-co-ordinated copper atoms are not required to have any symmetry; in fact the co-ordination is square pyramidal, with mean base Cu–O bonds 1·94(1) Å, and the axial Cu–N at 2·250(17) Å.

11.4 FENTON, D. E. (1973) Alkali-metal complexes of phenacyl kojate (5-phenacyloxy-2-hydroxymethyl-4*H*-pyran-4-one). *Journal of the Chemical Society* (*Dalton Transactions*) 1380–1383.

Complexes of the type MX, (phenacyl kojate) have been prepared where MX = CsBr, NH_4Br, RbI, CsI, NH_4I, NaNCS, KNCS, RbNCS and CsNCS. When MX = NaCl, KCl, RbCl, CsCl,

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NH_4Cl, NaBr, KBr, RbBr, NaI and KI, complexes of the type MX (phenacyl kojate)$_2$ are formed.

11.5 FENTON, D. E., NAVE, C. & TRUTER, M. R. (1973) Anionic hexafluoroacetylacetonato complexes of alkali and other metals and the crystal structure of dirubidium tris(hexafluoroacetylacetonato)sodiate. *Journal of the Chemical Society* (*Dalton Transactions*), 2188–2194.

Anionic alkali-metal complexes of the types $M(hfac)_2^-$ and $M(hfac)_3^{2-}$ are reported (hfac = $(CF_3CO)_2CH$). The counter ions present are mono-protonated, 1,8-bis(dimethylamino)-naphthalene $[C_{14}H_{19}N_2]^+$, or alkali metals. The preparations of the complexes $[C_{14}H_{19}N_2]^+$-$[M(hfac)_3]^-$ (M = Cu, Mg, Ni, or Mn) and $[C_{14}H_{19}N_2]^+[Tl(hfac)_2]^-$ are also reported.

The crystal structure of dirubidium tris(1,1,1,5,5,5-hexafluoropentane-2,4-dionato)sodiate, $(Rb^+)_2([CF_3COCHCOCF_3]_3Na)^{2-}$, has been determined. There are four molecules in an orthorhombic cell of space group $P2_12_12_1$. Sodium is surrounded by a trigonal prism of oxygen atoms (Na–O 2·20–2·47 Å), three chelate β-diketonates forming the prism sides. The rubidium ions contact fluorine and oxygen atoms from different anions.

11.6 HUGHES, D. L. (1973) Alkali-metal complexes. Part VII. Crystal and molecular structures of the *o*-Nitrophenolatobis-(1,10-phenanthroline) complexes of sodium and rubidium. *Journal of the Chemical Society* (*Dalton Transactions*), 2347–2354.

The alkali-metal salts of *o*-nitrophenol on treatment with the neutral chelating ligand 1,10-phenanthroline yield the co-ordinatively saturated 1 : 2 complexes named in the title. The structures of these have been determined by X-ray analysis with observations collected on a diffractometer.

In the sodium complex, the cation is six-co-ordinate, interacting with the three chelating ligands to give monomeric units. The rubidium complex has a similar pseudo-three-fold symmetry of the chelating ligands, but with a larger co-ordination sphere, the cation also accepts co-ordination with a second *o*-nitrophenolate ion, which thus bridges cations about a centre of symmetry. Dimeric units, bound by van der Waals' forces, form the crystal structure.

11.7 HUGHES, D. L. (1973) Crystal structure of thallium(I) L-ascorbate. *Journal of the Chemical Society* (*Dalton Transactions*), 2209–2215.

The thallium derivative of ascorbic acid was prepared by Prof. R. M. Synge and Mr. W. M. Laird for use as a coupling agent in the synthesis of 'ascorbalamic acid'. Crystals of the title compound are orthorhombic, space group $P2_12_12_1$. There are two molecules per asymmetric unit, related by a pseudo-two-fold axis parallel with the a axis. The two thallium(I) ions are 4·05 Å apart and bridged by oxygen atoms. Co-ordination about the cations is typically asymmetric, involving only three and four oxygen atoms (from four anions); in each case the oxygens are grouped on one side of the thallium ion.

The absolute configuration of the anions was assigned by comparison with L-ascorbic acid, and the differences between the geometry of these anions and that of sodium ascorbate are discussed.

11.8 (LAYTON, A. J.), MALLINSON, P. R., PARSONS, D. G. & TRUTER, M. R. (1973) Synthesis and crystal structures of complexes between caesium thiocyanate and two isomeric macrocyclic crown polyethers, 6,7,9,10,17,18,20,21-Octahydro-7R,9R,18S,20S-tetramethyldibenzo[b,k][1,4,7,10,13,16]hexaoxacyclo-octadecin (Isomer F) and 6,7,9,10,17,-18,20,21 - octahydro - 7R,9R,18R,20R - tetramethyldibenzo[b,k][1,4,7,10,13,16]hexaoxacyclo-octadecin (Isomer G). *Journal of the Chemical Society* (*Chemical Communications*), 694–695.

Two isomers, F and G, of tetramethyldibenzo-18-crown-6 each with four chiral carbon atoms give complexes with caesium thiocyanate; CsNCS(F) consists of centrosymmetrical dimeric molecules with Cs-N-Cs bridges, the other co-ordinating atoms being the six oxygens of F at 3·07–3·34 Å and the aryl carbon atoms at 3·79 Å, while $CsNCS(G)_2$ consists of $Cs(G)_2^+$ cations

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having $\bar{4}$ symmetry with 12 Cs-O contacts at 3·17–3·43 Å and disordered thiocyanate ions. Isomer F is the *meso* form while isomer G is optically active; the two molecules of G in the complex comprise one of each hand.

11.9 MERCER, M. & TRUTER, M. R. (1973) Crystal structures of complexes between alkali-metal salts and cyclic polyethers. Part VI. Complex formed between dicyclohexyl-18-crown-6, isomer B (perhydrodibenzo[b,k][1,4,7,10,13,16]hexaoxacyclo-octadecin) and sodium bromide. *Journal of the Chemical Society* (*Dalton Transactions*), 2215–20.

Reaction between sodium bromide and dicyclohexyl-18-crown-6, isomer B, in dry methanol gives a 1 : 1 complex with two molecules of water of hydration. The crystals are triclinic and three-dimensional X-ray analysis has shown that the sodium ion lies on a centre of symmetry, and is surrounded by an approximately planar ring of six oxygen atoms of one ligand (Na-O 2·67–2·97 Å). The hexagonal bipyramidal arrangement about the sodium is completed by two water molecules, at 2·34 Å. The water molecules form hydrogen bonds to the bromide ion, resulting in an infinite chain structure.

11.10 MERCER, M. & TRUTER, M. R. (1973) Crystal structures of complexes between alkali-metal salts and cyclic polyethers. Part VII. Complex formed between dibenzo-24-crown-8 (6,7,9,10,12,13,20,21,23,24,26,27-dodecahydrodibenzo[b,n]-1,4,7,10,13,16,19,-22-octaoxacyclotetracosin) and two molecules of potassium isothiocyanate. *Journal of the Chemical Society* (*Dalton Transactions*), 2469–2473.

Potassium thiocyanate reacts with dibenzo-24-crown-8 giving crystals of formula $C_{24}H_{32}O_8$, 2KNCS. The crystal structure has been determined. Crystals are monoclinic, space group $P2_1/c$, with $Z = 2$.

The ligand oxygen atoms are almost coplanar, with potassium atoms 0·66 Å on each side of this plane. Each K^+ atom is within bonding distance of five oxygen atoms, three bonding independently, (K–O 2·732–2·825 Å) and the fourth and fifth unequally shared between the two potassium atoms (K–O 2·898, 2·979 Å). One thiocyanate ion is above and one below the ligand ring plane, each bridging the two potassium ions through nitrogen (K–N 2·87, 2·88 Å).

11.11 MERCER, M. (CRABTREE, R. H. & RICHARDS, R. L.) (1973) A μ-dinitrogen complex with a long N–N bond. X-ray crystal structure of $[(PMe_2Ph)_4ClReN_2MoCl_4(OMe)]$. *Journal of the Chemical Society* (*Chemical Communications*), 808–809.

The complex $[(PMe_2Ph)_4ClReN_2MoCl_4(OMe)]$ has been prepared; it has $\nu(N_2)$ at 1660 cm^{-1} and the N–N (1·21 Å), Re–N (1·79 Å), and Mo–N (1·89 Å) bond distances, determined by X-ray crystallography are consistent with a linear Re–N–N–Mo delocalised bonding scheme.

11.12 NAVE, C. & TRUTER, M. R. (1973) Crystal structure of bromo-[tris-(2-vinylphenyl)-phosphine]rhodium(I). *Journal of the Chemical Society* (*Dalton Transactions*), 2202–2204.

The crystal structure of the title organometallic compound has been determined. It is rhombohedral, the rhodium, phosphorus and bromine atoms lie on a three-fold axis which relates the vinylphenyl groups. The six olefinic carbon atoms are equidistant from the rhodium atom (Rh–C 2·22 and 2·25 Å) which is displaced from the equatorial plane by 0·10 Å towards the bromine, to give Rh(I)–Br 2·581(4) and Rh–P 2·167(11) Å.

11.13 POONIA, N. S. & TRUTER, M. R. (1973) Complexes of alkali-metal salts, including those of chelating anions, with four macrocyclic 'crown' ethers. *Journal of the Chemical Society* (*Dalton Transactions*), 2062–2065.

An investigation of the effect of solvent, presence of water, and ratio of reactants on the isolation of complexes between LiX (X = Br, I, NCS) with benzo-15-crown-5(1) and of NaX and KX with (1), dibenzo-18-crown-6(2), dibenzo-24-crown-8(3), and dibenzo-30-crown-10(4) has led to several new complexes, particularly those with two metal atoms to one ligand. For sodium and

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potassium with X = 1-nitroso-2-naphtholate, 2-nitrophenolate, 2,4-dinitrophenolate, and 2-hydroxybenzoate, complexes have been made with ligands (1)–(3). These include [(sodium 2-nitrophenolate)$_2$(3)] and [potassium hydrogen(2-nitrophenolate)$_2$-(1)$_2$].

Statistics Department

General Papers

12.1 (Alderman, G., Edwards, R. A., Griffiths, J. R., Holmes, W.), Lessells, W. J. (Morgan, D. E. & Raven, A. M.) (1974) An approach to the practical application of a metabolisable energy system for ruminants in the United Kingdom. *Proceedings of the 7th Nutrition Conference for Feed Manufacturers, January 1973, School of Agriculture, Sutton Bonington*, pp. 37–78.

12.2 Alvey, N. G. (1973) *Table operations. Genstat User's Guide No. 6.* Inter-University/Research Council Series, Report No. 20. Edinburgh: Program Library Unit, Edinburgh Regional Computing Centre, 23 pp.

12.3 Gower, J. C. (1973) *Matrix operations. Genstat User's Guide No. 5.* Inter-University/Research Council Series, Report No. 19. Edinburgh: Program Library Unit, Edinburgh Regional Computing Centre, 16 pp.

12.4 Gower, J. C. & Ross, G. J. S. (1974) *Multivariate and cluster analysis. Genstat User's Guide No. 4.* Inter-University/Research Council Series, Report No. 18. Edinburgh: Program Library Unit, Edinburgh Regional Computing Centre, 55 pp.

12.5 Gower, J. C. & (Mardia, K. V.) (1974) Multivariate analysis and its applications: A report on the Hull Conference 1973. *Applied Statistics* **23**, 60–66.

12.6 Nelder, J. A. (1973) *The GENSTAT Language. Genstat User's Guide No. 1.* Inter-University/Research Council Series, Report No. 15. Edinburgh: Program Library Unit, Edinburgh Regional Computing Centre, 24 pp.

12.7 Nelder, J. A. (1973) *GLIM (Generalised Linear Interactive Modelling). User's Manual.* Duplicated Report: Working Party on Statistical Computing of the Royal Statistical Society, 19 pp.

12.8 Nelder, J. A. & Members of the Rothamsted Statistics Department (1973) *Genstat Reference Manual.* Inter-University/Research Council Series, Report No. 3, Second Edition. Edinburgh: Program Library Unit, Edinburgh Regional Computing Centre, 163 pp.

12.9 Wedderburn, R. W. M. (1973) *Regression. Genstat User's Guide No. 3.* Inter-University/Research Council Series, Report No. 17. Edinburgh: Program Library Unit, Edinburgh Regional Computing Centre, 16 pp.

Research Papers

12.10 (Andrews, A. H.) & Wedderburn, R. W. M. (1973) The relationship of age to first molar tooth development in a group of cross-bred steers. *British Veterinary Journal* **129**, 512–517.

The relationship of first molar (fourth cheek) tooth eruption to age in groups of Hereford × Friesian steers is examined. A scheme for scoring visual assessment of the degree of intra-oral eruption is described. A mathematical model relating observed scores to the known ages gives estimates of the age corresponding to any observed score, together with an estimate of error.

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Eruption of the first molar gives a useful indication of age in the range five months to one year, a time when intra-oral eruption of the permanent anterior teeth has not begun.

12.11 BOYD, D. A. (1973) Developments in field experimentation with fertilizers. *Phosphorus in Agriculture* No. 61, pp. 7–17.

A brief historical review is followed by an account of some of the more important developments in field experimentation in Britain. There has been a trend from isolated experiments to carefully planned series of experiments, whereby the effect on the fertiliser requirement of crops of such important factors as kind of soil, crop rotation and season are being identified. In place of designs testing few amounts of fertiliser, multi-level experiments testing up to nine amounts of a single nutrient and six amounts of all three nutrients are giving fresh insight into yield/nutrient relationships.

Some common misunderstandings over the use of standard errors and the analysis of variance are discussed.

12.12 CHURCH, B. M. & (CALDWELL, T. H.) (1973) Lime requirements and the lime status of soils in England and Wales, 1963–68. *Experimental Husbandry* No. 24, 48–53.

Information on the lime reserves of soils and estimates of changes between 1963 and 1968 are given from a survey of 13 districts of England and Wales.

On average, the lime status of soils remained in balance; losses of $CaCO_3$ in the five-year period about equalled the 2·1 t/ha used. However, if losses continue at the same rate, the decreased use of lime since 1968 implies that there could now be a run-down in the reserves of some soils. Lime was lost most quickly from recently-limed fields, and losses were larger at higher pH and more for tillage than for grass fields.

Requirements for future surveys of soil nutrient status, which should have limited objectives, are discussed.

12.13 GOWER, J. C. (1973) Classification problems. *Contributed papers, 39th Session of the International Statistical Institute*, **1**, 402–408.

Examining non-probabilistic classification models is essential before their probabilistic counterparts can be properly formulated. Classification has many purposes, but often criteria are concerned with the future use of the classes, such as their predictive properties or the ease and accuracy with which future samples can be correctly assigned.

12.14 GOWER, J. C. (1974) Relating classification to identification. In: *Automatic identification of biological specimens.* London: Academic Press.

Multivariate mixture and discriminant problems, which are respectively classical statistical and identification problems, are shown to be closely interrelated. This is just one example of the rigid distinction between classification and identification becoming blurred. Another example is given relating non-probabilistic classification and identification. It is suggested that these are not isolated cases, but that classes are often set up so that future samples can be assigned to them optimally.

12.15 GOWER, J. C. (1974) The analysis of three-way grids. In: *Intra personal space—the measurement of subjective variation by grid technique.* Ed. P. Slater. London: Wiley

A two-way grid is a special kind of two-way table arising in psychological work, and shows how an individual views various persons of his acquaintance. The rows refer to the persons and the columns to various attitudes. Such tables may be analysed by fitting a multiplicative model with row × column terms and this is closely related to principal components analysis. When several grids have been collected for different individuals, or for the same individual on different occasions, a three-way grid must be analysed. The paper develops various ways in which the multiplicative model may be generalised and examines the associated computational problems. Allied methods for analysing sets of tables are briefly reviewed.

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12.16 KEMPTON, R. A., BARDNER, R., FLETCHER, K. E., JONES, M. G. & (MASKELL, F. E.). (1974) Fluctuations in wheat bulb fly egg populations in Eastern England. *Annals of Applied Biology* **77**, 102–107.

Fluctuations on mean egg densities from field samples in the ADAS Eastern Region for the past 20 years are analysed to determine what factors have important effects on egg density. In both light and heavy soils over 70% of the variation in egg density between years could be linked to variation of three factors: availability of egg-laying sites; autumn rainfall, affecting date of sowing of winter wheat; the January soil temperature, affecting date of hatching of the eggs.

12.17 KEMPTON, R. A. & TAYLOR, L. R. (1974) Log-series and log-normal parameters as diversity discriminants for the Lepidoptera. *Journal of Animal Ecology* **43**, 381–399.

(For summary see No. 10.40.)

12.18 LEECH, F. B. (1974) Handling epidemiological data. In: *Proceedings of the International Symposium on Dermatophilus Infection*, 1973.

In a survey to measure disease frequency the main problems are to obtain data about a representative sample of animals and to formulate a definition of the affected animal that can be applied consistently to the whole sample. In experiments and in surveys of disease natural-history hypotheses about causation or control determine the details of data collection. Analysis often requires a lot of calculation and the current lack of a computer program for survey analysis suitable for small computers hinders the proper assessment of epidemiological studies in many countries, particularly in the tropics.

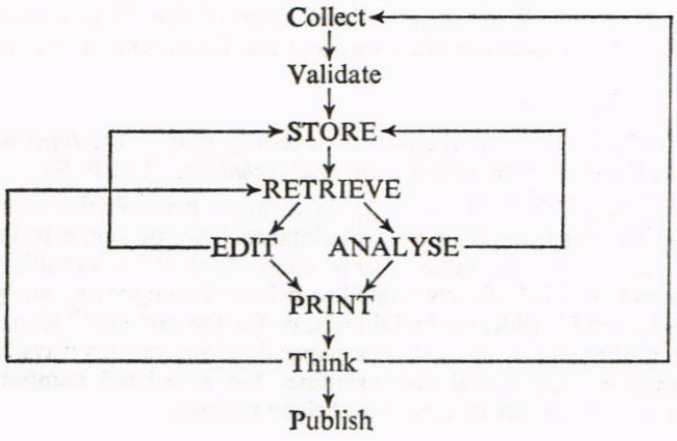
12.19 (LITTLE, R. C.) & TONG KWONG YUEN, LOWSING (1973) Variation in nutrient content of glasshouse soils. *Experimental Horticulture*, No. 25, 102–111.

The object was to find how best to sample soils from a block of glasshouses for reliable manurial advice. Differences between pairs of samples from the same bed were 5–10% for salt concentration and potassium, but up to 30% for nitrate-nitrogen. However, the nutrient contents of beds within most houses were similar. At most sites differences between houses on the first sampling date were small, but on a few sites they were larger and often inconsistent from one time of sampling to the next.

An adequate sampling procedure would be to take a single sample at random from the whole of each house on the first occasion, but from a selection of houses on later occasions whenever house-to-house differences at the first sampling were small.

12.20 NELDER, J. A. (1974) GENSTAT facilities and data-logging. In: *Proceedings of Data-Logging Symposium, N.I.A.E.*

The diagram illustrates activities in a scientific project involving data-logging:



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Genstat provides facilities for all the activities in capitals. The scope of these facilities is illustrated and the steps necessary to make files of previously validated data acceptable to the Genstat system are discussed.

12.21 PAYNE, R. W. (1974) Genkey: a program for constructing diagnostic keys. In: *Automatic identification of biological specimens*. London: Academic Press.

Genkey is a Fortran computer program for constructing diagnostic keys from a matrix giving the responses of each species to tests, together with certain ancillary information. The paper describes the methods used in Genkey and the options available in, for example, mode of construction, test selection, use of probabilities and forms of output.

12.22 (PREECE, D. A.) & GOWER, J. C. (1974) An iterative computer procedure for mixed-up values in experiments. *Applied Statistics* **23**, 73–74.

Healy and Westmacott (1956) gave an iterative computer procedure for dealing with missing values in experiments. Pearce (1965) and others discussed an improved version of the procedure. This improved version is now extended to deal with inadvertently pooled values.

12.23 ROGERS, C. E. (1973) Interpreting structure formulae. *Applied Statistics* **22**, 414–424.

Structure formulae resembling ordinary algebraic expressions can specify compactly the structure of factorial experiments. An algorithm is given to translate any structure formula into the equivalent list of model terms.

12.24 ROSS, G. J. S. (1974) Rapid techniques for automatic identification. In: *Automatic identification of biological specimens*. London: Academic Press.

Simple identification techniques may be sufficient for many applications, and rapid processing allows the computer user to try different approaches. The identification facilities in the author's program CLASP are described, including the construction of binary keys, finding the approximate minimum subset of variates for binary identification, identification by similarity coefficients, and the analysis of clusters to find useful identification variates.

12.25 (SPARKS, D. N.) & TODD, A. D.(1973) Latent roots and vectors of a symmetric matrix. *Applied Statistics* **22**, 260–265.

An algorithm consisting of Fortran translations of two Algol subroutines is described. One subroutine reduces a real symmetric matrix to tri-diagonal form using Householder's reduction and the other finds the latent roots and vectors of a symmetric tri-diagonal matrix, using QL transformations.

12.26 (SPARKS, D. N.) & TODD, A. D. (1973) A comparison of Fortran subroutines for calculating latent roots and vectors. *Applied Statistics* **22**, 220–225.

This paper compares the accuracy, speed and storage requirements of the algorithm described in paper 25 above, with those of the algorithm by Ortega in *Mathematical methods for digital computers*, Vol. II. Ed. A. Ralston and A. H. Wilf. New York: Wiley.

12.27 WILDING, N. & LAUCKNER, F. B. (1974) *Entomophthora* infecting wheat bulb fly at Rothamsted, Hertfordshire, 1967–71. *Annals of Applied Biology* **76**, 161–170.

(For summary see No. 10.55.)

12.28 WILKINSON, G. N. & ROGERS, C. E. (1973) Symbolic description of factorial models for analysis of variance. *Applied Statistics* **22**, 392–399.

The paper describes the symbolic notation and syntax for specifying factorial models for analysis of variance in the control language of the Genstat 5 statistical program system at Rothamsted. The notation generalises the structure-formulae described by Nelder (1965). Algorithm AS 65

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(C. E. Rogers, ref. no. 23) converts structure-formulae in this notation to a list of model terms represented as binary integers.

A further extension of the syntax is discussed for specifying models generally (including non-linear forms).

Computer Department

Research Paper

13.1 Yates, F. (1974) The early history of experimental design. *Proceedings of the International Symposium on Statistical Design and Linear Models, Colorado State University, 1973.*

This paper gives an account of the development of the modern science of experimental design and analysis to which R. A. Fisher and his co-workers at Rothamsted made such outstanding contributions. This work is even now not fully understood by some mathematical statisticians.

Field Experiments Section

Book

14.1 Dyke, G. V. (1974) *Comparative experiments with field crops.* London: Butterworth, 211 pp.

Broom's Barn Experimental Station

Theses

16.1 Durrant, M. J. (1973) Effects of plant population, irrigation and nutrition in the sugar beet crop. For Membership of the Institute of Biology.

16.2 Longden, P. C. (1973) The control of yield and quality of sugar-beet seed. Ph.D. Thesis, University of Nottingham.

General Papers

16.3 Baker, A. N. (1974) Some aspects of the economic importance of millepedes. *Symposia of the Zoological Society of London* **32.**

16.4 Cooke, D. A., Dunning, R. A. & Winder, G. H. (1973) Control of sugar-beet Docking disorder: trials comparing spring application of fumigants and aldicarb. *Annals of Applied Biology* **75**, 460.

16.5 Draycott, A. P. (1973) Measurement of soil moisture deficit by neutron moderation under two densities of sugar beet with and without irrigation. Physical aspects of soil water and salts in ecosystems. *Ecological Studies* **4.** Berlin: Springer-Verlag, pp. 309–314.

16.6 Draycott, A. P. & Farley, R. F. (1973) Manganese; vital trace element. *British Sugar Beet Review* **41**, 21–27.

16.7 Dunning, R. A. (1973) Pygmy beetle. *Ministry of Agriculture, Fisheries and Food Advisory Leaflet* No. 589, 5 pp.

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16.8 HEATHCOTE, G. D. (1973) Control of viruses spread by invertebrates to plants. In: *Viruses and invertebrates. North-Holland Research Monographs 'Frontiers of Biology'* **31**, 587–609.

16.9 HEATHCOTE, G. D. (1973) Growth stages of the sugar beet root crop (4.4.7/1). Growth stages of the sugar beet seed crop (4.4.7/2). In: *FAO Manual on the evaluation and prevention of losses by pests, diseases and weeds.* Rome.

16.10 HEATHCOTE, G. D. (1974) Lacewings. *Suffolk Natural History* **16**, 220–223.

16.11 HEATHCOTE, G. D. (1974) Cleaner-loader sites and crop hygiene. *British Sugar Beet Review* **42**, 30–32.

16.12 HEATHCOTE, G. D. (RUSSELL, G. E. & VAN STEYVOORT, L.) (1973) Crop loss assessment methods 99. Beet yellows, beet mild yellowing and beet western yellows viruses. In: *FAO Manual on the evaluation and prevention of losses by pests, diseases and weeds.* Rome.

16.13 HULL, R. (1974) Observations on the Joint ASSBT-IIRB 1973 Congress in North America. *International Sugar Journal*, August 1973, 15–16.

16.14 HULL, R. (1974) Integrated control of pests and diseases of sugar beet. In: *Biology in Pest and Disease Control.* Oxford: Blackwell Scientific Publications, pp. 269–276.

RESEARCH PAPERS

16.15 BAKER, A. N. (1973) Factors contributing towards the initiation of slug activity in the field. *Proceedings of the Malacological Society of London* **40**, 329–333.

The initiation of slug activity was studied under field conditions with *Agriolimax reticulatus* (Müll), using an aktograph sensitive to movement in conjunction with a continuous record of temperature and relative humidity. These two factors played a part in stimulating activity, which may under some conditions take the form of an exogenous rhythm of activity and rest. The complexity of the stimuli involved in the initiation of activity was implicated in the recordings.

16.16 COOKE, D. A., DUNNING, R. A. & WINDER, G. H. (1974) The effect of nematicides, applied to the seed rows in spring, on growth and yield of sugar beet in Docking-disorder-affected fields. *Annals of Applied Biology* **76**, 289–298.

Both *Trichodorus* spp. and *Longidorus* spp. damage roots of sugar-beet seedlings in sandy soil, causing Docking disorder. Trials in infested fields between 1969 and 1972 tested the effects of fumigation along the rows with different amounts of 'D-D' or 'Telone' applied either two weeks before sowing or immediately before sowing, application of the systemic nematicide, aldicarb, ('Temik') in the furrow with the seed during sowing, and top-dressing with nitrogen. Seedling establishment was often decreased by fumigation immediately before sowing, especially when followed by excessive rainfall, but only rarely by earlier fumigation or by aldicarb; differences in numbers of roots harvested were smaller because hand-singling removed excess seedlings. There was usually little difference between the yield increases given by the most effective treatments, which were aldicarb at 1·12 kg active ingredient/ha and 2·2–6·6 ml 'D-D' or 'Telone'/m of row at either time of application. Nitrogen top-dressing never affected sugar yield significantly. *Longidorus* spp. and *Trichodorus* spp. were both controlled well in the fumigated row but much less well at 13 cm, and not at all at 25 cm from the row (i.e. mid-way between two treated rows).

16.17 COOKE, D. A. (1973) The effect of plant parasitic nematodes, rainfall and other factors on Docking disorder of sugar beet. *Plant Pathology* **22**, 161–170.

In the years 1963 to 1972 the area of sugar beet reported affected with Docking disorder ranged from 174 to 7819 ha. It was most wide-spread after heavy May rainfall. *Trichodorus* spp. and *Longidorus* spp. cause the primary damage to seedling roots and are common in sandy soils on

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which much sugar beet is grown. Nematode numbers in soil samples taken at drilling were not correlated with root yield or shape. Accurate prediction of damage is impossible because it is influenced by growing conditions but is more likely to be severe in fields with a previous history of the disorder.

16.18 DRAYCOTT, A. P., DURRANT, M. J. & MESSEM, A. B. (1974) Effects of plant density, irrigation and potassium and sodium fertilisers on sugar beet. II. Influence of soil moisture and weather. *Journal of Agricultural Science (Cambridge)* **82**, 261–268.

The amount of soil moisture used by sugar beet was determined weekly between May and October (1970–72) in plots testing 18 500 and 124 000 plants/ha with and without irrigation. When leaves covered more than 60% of the ground (after mid-June with the large population and after mid-July with the small population) the crop used water at the potential transpiration rate even with soil moisture deficits on plots without irrigation of up to 170 mm. Therefore as irrigation greatly increased sugar yield in 1970 and 1972, it probably did not do so simply by satisfying the crop's water need.

In 1970 irrigation appeared to act partly by decreasing the time taken to attain complete leaf cover but in 1972 irrigation had only a slight effect on leaf cover but greatly increased sugar yield, particularly of the large population. With little rainfall, the large population rapidly exhausted the available moisture from the plough layer. It seems likely therefore that irrigation increased yield by giving more leaf cover early and by improving nutrient supply but not by supplying extra water for transpiration.

Roots of the larger plant population extended deeper more rapidly than those of the small plant population but roots of both eventually reached 150 cm. This probably explains why the crop was able to use water at the potential rate for much of the season even in prolonged droughts. The maximum amount of water removed from each soil horizon depended on plant population, the water treatments and depth down the profile. The available water capacity estimated from soil texture suggested that with roots to 150 cm, there was 236 mm of available water in the soil. In practice, 124 000 plants/ha given no irrigation used 167 mm of this and 115 mm when irrigation was applied. These experiments, like earlier ones, suggest that on this soil sugar beet only gives large responses to irrigation when it is needed early in the season.

16.19 DRAYCOTT, A. P., DURRANT, M. J. & WEBB, D. J. (1974) Effects of plant density, irrigation and potassium and sodium fertilisers on sugar beet. I. Yields and nutrient compositions. *Journal of Agricultural Science (Cambridge)* **82**, 251–260.

Three experiments (1970–72) on calcareous sandy loam tested all combinations of four plant populations (18 500–124 000 plants/ha), two amounts of potassium (0 and 156 kg/ha K) and sodium (0 and 247 kg/ha Na) fertiliser and two watering treatments on yield and chemical composition of sugar beet. The main effects of the treatments in all three experiments confirmed that at least 75 000 plants/ha were needed for maximum sugar yield, that sodium fertiliser increased sugar yield more than potassium (+0·76 and +0·27 t/ha respectively) and that the crop responded to irrigation in some years (+1·35 t/ha sugar in 1970 and +1·67 t/ha in 1972).

Analysis of the growth of the crop showed that increasing the plant population increased leaf growth per unit area from singling onwards and giving irrigation increased it from July; the effects persisted until harvest and were reflected in increased sugar yields. Fertiliser increased leaf growth early in the season but the effect disappeared later, although sugar yield was still increased. Interactions between plant population, fertiliser treatment and irrigation were small every year but there were some consistent effects on sugar yield. The results suggest that in commercial practice the optimum population is 75 000 plants/ha; where irrigation is not practised, 247 kg/ha sodium plus 75 kg/ha potassium fertiliser should be given. Where irrigation is applied, only 247 kg/ha sodium needs to be given as the extra water increases the uptake of soil potassium.

16.20 DRAYCOTT, A. P. & FARLEY, R. F. (1973) Response by sugar beet to soil dressings and foliar sprays of manganese. *Journal of the Science of Food and Agriculture* **24**, 675–683.

Responses by sugar beet to manganese in 16 field experiments on organic soils is reported. Soil applications of manganous oxide and manganese silicate 'frit' were compared with foliar sprays

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of manganese sulphate equivalent to 9 and 18 kg/ha Mn in seven experiments (1969–71); three experiments during the same period tested up to three sprays of manganese sulphate, each equivalent to 9 kg/ha Min, on severely manganese-deficient crops. Six previous experiments (1936–41) compared soil applications of manganese sulphate, in the seedbed and as top-dressings, with foliar sprays of manganese sulphate in amounts up to 42 kg/ha Mn to the soil and up to 1·5 kg/ha Mn in the sprays.

The manganous oxide and the silicate 'frit' did not prevent deficiency and increased neither the concentration of manganese in the leaves during the growing season nor the sugar yield at harvest. Manganese sulphate sprays increased the concentration of manganese in the leaves, cured most of the symptoms and increased sugar yield by up to 1·5 t/ha. On average of the 10 experiments 1969–71, the crop responded little to treatment when less than 20% of plants showed symptoms. When 21 to 60% of plants were affected, the sprays increased sugar yield by 5% and by 17% when more than 60% were affected. Of several extractants tested, the fraction of soil manganese extracted by normal ammonium acetate buffered to pH 7·0 and containing hydroquinone was best correlated with the concentration of manganese in the leaves. The early experiments showed that large soil dressings of manganese sulphate controlled symptoms and increased sugar yield but sprays applying much smaller quantities were equally effective.

16.21 DRAYCOTT, A. P., WEBB, D. J. & WRIGHT, ELIZABETH M. (1973) The effect of time of sowing and harvesting on growth, yield and nitrogen fertiliser requirement of sugar beet. I. Yield and nitrogen uptake at harvest. *Journal of Agricultural Science (Cambridge)* **81**, 267–275.

Four field experiments (1968–71) investigated the effect of changing the length of the growing period on the nitrogen fertiliser requirement of sugar beet. The crop was sown on three occasions (March–May), harvested on three occasions (September–December) and given four amounts of fertiliser (0–225 kg/N/ha). Plant samples were analysed at several stages of growth (1969–71) in an attempt to predict the amount of nitrogen fertiliser needed for maximum sugar yield and also at the end of the season to determine the nitrogen uptake. Increasing the length of the growing period increased sugar yield greatly but the amount of nitrogen fertiliser needed for maximum sugar yield was unchanged. The crop given the largest dressing of nitrogen and with the longest growing period contained most total nitrogen, but in every experiment, giving more than 75 kg/ha N neither increased nor decreased the sugar yield significantly. As a result of the small variations in nitrogen requirement, the plant analyses during the growing season were of little value in predicting the needs of the crop.

16.22 DUNNING, R. A. (1974) Bird damage to sugar beet. *Annals of Applied Biology* **76**, 325–335.

Since sugar beet pest damage records started in 1957, damage by birds, especially grazing of seedlings, has greatly increased, most probably as a result of changing agronomic practices, especially the extensive use of herbicides, the introduction of monogerm seed, and the increase in planting-to-a-stand. The distribution of the reported damage does not seem to follow any national pattern. In small-plot field trials possible repellent materials such as anthraquinone, methiocarb or thiram, applied to seed or foliage, did not decrease the extent of grazing.

16.23 DUNNING, R. A. & WINDER, G. H. (1974) Seed-furrow application of pesticides for the protection of sugar-beet seedlings from pest damage. *Proceedings of the 7th British Insecticide and Fungicide Conference, Brighton, 1973*, pp. 501–511.

Pesticides applied in the seed furrow were tested in trials on both pest-infested and pest-free sugar-beet fields in 1970 to 1973. Aldicarb granules, methiocarb liquid and 'Du Pont 1410' granules or liquid, at rates of one-quarter to 1 lb a.i./acre (280 to 1120 g/ha), were consistently beneficial in protecting seedlings from damage by soil pests, mainly pygmy beetle and millepedes. Bendiocarb, gamma-BHC (granules only), carbofuran, diazinon, mecarphon, 'AC 92100', 'CGA 12223' and 'PP 505' are worth further testing but many other materials were ineffective or phytotoxic.

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16.24 DUNNING, R. A. & WINDER, G. H. (1974) Effects of aldicarb and some other nematicides on growth of sugar beet in *Heterodera schactii*-infested soil. *Plant Pathology* **23**, No. 1.

The vigour and yield of sugar beet grown on *Heterodera schachtii*-infested soils, with organic matter contents of 14–68%, were increased by aldicarb granules applied in the seed furrow in field trials in Eastern England in 1968 to 1970. Sugar yields were smallest on the most heavily infested sites; yield increases on plots treated with aldicarb were greatest at doses ranging from 11 to 31 oz a.i./acre (770–2170 g/ha), but increases were not enough to ensure a satisfactory crop. Post-crop numbers of cyst eelworm were not decreased by treatment. Other candidate nematicides—chlorfenvinphos, diazinon, fensulfothion, methomyl, 'Neosar', 'Du Pont 1410', pirimiphosmethyl, 'Prophos', thionazin, 'BTS 18502', 'C14421' and 'R17210'—had no beneficial effect and several, especially at higher doses, were phytotoxic.

16.25 DURRANT, M. J., LOVE, B. J. G., MESSEM, A. B. & DRAYCOTT, A. P. (1973) Growth of crop roots in relation to soil moisture extraction. *Annals of Applied Biology* **74**, 387–394.

Growth of the roots of sugar beet, potato and barley in the field was observed through glass panels and related to changes in soil moisture measured by a neutron probe during 1969–71. The depth of observed root growth was generally related to, but 10–15 cm deeper than, the maximum depth of soil-moisture extraction. On average of three years, sugar beet, potato and barley used water from the top 23, 33 and 45 cm soil respectively by the beginning of June, and from the top 70, 68 and >100 cm soil by the end of June. Maximum soil drying in each horizon gave an *in situ* measure of available water capacity, and showed that sugar beet and barley eventually extracted similar amounts of water from each horizon, but potatoes extracted less, especially from below 60 cm. Between 30 and 100 cm deep, the *in situ* available water capacity (per 10 cm soil) progressively decreased from 16 to 10, 15 to 5 and 16 to 8 mm under sugar beet, potato and barley respectively. The calculated soil-moisture deficit (potential evapotranspiration minus rainfall) and measured soil moisture deficit were not related early in the growing period before the crops established much leaf cover.

16.26 HEATHCOTE, G. D. (1973) Nematode-transmitted viruses of sugar beet in England, 1965–72. *Plant Pathology* **22**, 156–160.

Tobacco rattle virus (TRV) occurs in about 10%, and tomato blackring virus (TBRV) in about 5% of sugar-beet fields affected with Docking disorder. Leaf symptoms caused by TRV and by TBRV may be indistinguishable. Sugar-beet plants in the field showing TRV in June were symptomless in October, and plants infected with TBRV through the seed were symptomless under glasshouse conditions.

Treatment with either 'D–D' soil fumigant or the systemic nematicide methomyl decreased the proportion of plants showing TRV in the field. Neither TRV nor TBRV seems likely to cause a serious disease of sugar-beet crops.

16.27 HEATHCOTE, G. D. (1974) The effect of spacing, nitrogen fertiliser and irrigation on the appearance of symptoms and spread of virus yellows in sugar-beet crops. *Journal of Agricultural Science (Cambridge)* **82**, 53–60.

Where ample rather than little nitrogen fertiliser is used a small increase in the percentage of plants infected with yellows can be expected, and aphids will be more numerous. Irrigation may also increase yellows incidence, but any loss of potential yield from increased virus incidence will be small compared with that gained from the use of fertiliser or irrigation. However, plant density can appreciably affect yellows incidence.

16.28 LAST, P. J. & DRAYCOTT, A. P. (1972) Top-dressings of nitrogen for sugar beet. *Experimental Husbandry* **22**, 82–88.

Forty-three experiments between 1959 and 1964 compared the value of nitrogen fertiliser applied to sugar beet in the seedbed with split dressings.

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Nitrogen at 0·6 cwt/acre (75 kg/ha) N in the seedbed increased sugar yield by 9·4 cwt/acre (1·18 t/ha), and 0·9 cwt/acre (113 kg/ha) N gave maximum yield. On average, giving some nitrogen as a top-dressing had no significant effect on root or sugar yield but decreased sugar percentage and juice purity by 0·2 and 0·3% respectively. Top dressing had inconsistent effects on top growth; on average, it increased yield of tops by 0·25 ton/acre (0·63 t/ha).

Some crops showed slight advantage from top-dressing, but in every year the chance of depressing sugar yield and sugar percentage was enhanced by splitting the fertiliser. No crop on soil containing more than 1·7% organic carbon responded to top-dressing.

Rainfall and response to top dressed N were not closely correlated and a regression combining spring and early summer rainfall and percentage organic carbon in the 43 experiments accounted for only 13% of the total variance in yield response to top-dressing.

It is concluded that the whole of the nitrogen fertiliser for sugar beet should be given in the seedbed.

16.29 LONGDEN, P. C. & (SCOTT, R. K.) (1973) Growing sugar beet for seed in England. *ADAS Quarterly Review* No. 9, pp. 10–23.

About 1000t of sugar-beet seed are used annually in England. Seed crops, which total 1000 ha, are grown mainly south west of the Wash, but also in other suitable areas including Essex, Bedfordshire, Northants, Oxfordshire and Gloucestershire. Most crops are now growin *in situ*, undersown with barley. *In situ* growing without a cover crop is also practiced, particularly west of the M1 motorway, and a small, decreasing area is grown by the traditional transplanting method. Field experiments since 1964 have tested the effects of agronomic factors on seed yield and quality. Plant populations of 250 000/ha or more are necessary for maximum yield of *in situ* crops grown without cover. In the first year of growth 125 kg/ha P_2O_5 and up to 250 kg/ha K_2O are necessary for maximum yield and in the second year up to 250 kg/ha N, top dressed on the crop in early spring. Yield of seed declined by 20 kg/ha/day and germination by 0·15%/day with delays in sowing the *in situ* crop from early July until late August. At harvest, changes in development of yield and germination of seed are out of phase; by the time useful numbers of viable seeds exist yield is already declining and continues to decline at 30–40 kg/ha/day while germination increases by 1%/day. Tripodding, swathing and chemical killing of plants before direct combining gave similar yields, germination and size distribution of seed.

16.30 LONGDEN, P. C. (1974) Washing sugar-beet seed. *I.I.R.B. (Journal of the International Institute for Sugar Beet Research* **6**, 154–162.

Sugar beet seed gave faster and increased seedling emergence when washed for 3·5 hours with 21 changes of water at 25°C. The leachate retarded germination of cress seed. Different sugar-beet seed crop harvest dates and weather conditions at harvest (i.e. different years) had little effect on this response. Seed harvested from individual plants grown together under similar conditions differed in response to washing which suggested that selection for high germination without response to washing might give lines without inhibitor problems. After washing, eight out of 20 samples from commercial seed lots gave significantly more seedlings (average 9%) from compost in the glasshouse, and 10 showed an average of 4% increase in emergence. When the eight samples were sown in the field, seven gave from 3 to 11% (average 6%) more seedlings. Because of speeded emergence, seedlings about three weeks after sowing were 6% heavier from washed than unwashed seed.

Soil Survey

BOOKS

17.1 COPE, D. W. (1973) *Soils in Gloucestershire I: Sheet SO82 (Norton)*. Harpenden: Rothamsted Experimental Station, viii, 137 pp.

17.2 CORBETT, W. M. (1973) *Breckland Forest Soils*. Harpenden: Rothamsted Experimental Station, vii, 120 pp.

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17.3 FORDHAM, S. J. & GREEN, R. D. (1973) *Soils in Kent II: Sheet TR35 (Deal)*. Harpenden: Rothamsted Experimental Station, vii, 146 pp.

17.4 FURNESS, R. R. & KING, S. J. (1973) *Soils in Cheshire II: Sheet SJ37 (Ellesmere Port)*. Harpenden: Rothamsted Experimental Station, viii, 130 pp.

17.5 GREEN, R. D. & FORDHAM, S. J. (1973) *Soils in Kent I: Sheet TR04 (Ashford)*. Harpenden: Rothamsted Experimental Station, vii, 257 pp.

17.6 HARTNUP, R. & JARVIS, R. A. (1973) *Soils of the Castleford area of Yorkshire*. Harpenden: Rothamsted Experimental Station, viii, 100 pp.

17.7 JARVIS, M. G. (1973) *Soils of the Wantage and Abingdon district*. Harpenden: Rothamsted Experimental Station, viii, 200 pp.

17.8 JARVIS, R. A. (1973) *Soils in Yorkshire II: Sheet SE60 (Armthorpe)*. Harpenden: Rothamsted Experimental Station, viii, 107 pp.

17.9 (RAGG, J. M.) & CLAYDEN, B. (1973) *The classification of some British soils according to the comprehensive system of the United States*. Harpenden: Rothamsted Experimental Station, vii, 227 pp.

THESES

17.10 SMITH, P. D. (1973) Hydrological aspects of some soils in the Kingston Brook catchment. M.Phil. Thesis, University of Nottingham.

17.11 STAINES, S. J. (1973) Soils and vegetation on Dartmoor: distribution and history. M.Sc. Thesis, University of Bristol.

GENERAL PAPERS

17.12 ALLEN, R. H. (1971) The Soil Survey of England and Wales in Essex. *Essex Naturalist* **22**, 361–362.

17.13 ALLEN, R. H. (1972) Problems and complexities of Essex geology. *Essex Field Club Bulletin* No. 7, 2–4.

17.14 ALLEN, R. H. & (COWLIN, R. A. C.) (1971) Badgers in relation to geology in Essex. *Essex Naturalist* **22**, 307–312.

17.15 BENDELOW, V. C. (1973) Mapping the Pennine soils. *Dalesman* **35**, 378–381.

17.16 CARROLL, D. M. (1973) Remote sensing techniques and their application to soil science. Part 1. The photographic sensors. *Soils and Fertilizers* **36**, 259–266.

17.17 (CASSON, J.), HARTNUP, R. & JARVIS, R. A. (1973) Soil surveys for integrated land use planning. *Journal of the Royal Town Planning Institute* **59**, 400–406.

17.18 EVANS, R. (1973) Aerial photographs for soil survey. *Bede Transects* **1**, 34–38.

17.19 GREEN, R. D. (& BURNHAM, C. P.) (1973) Soils. In: *The rural landscape of Kent*. Wye College, pp. 49–75.

17.20 JOHNSON, P. A. (1973) The soils of the Tideswell area. *Proceedings of the North of England Soils Discussion Group* No. 8, 23–35.

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Research Papers

17.21 Avery, B. W. (1973) Soil classification in the soil survey of England and Wales. *The Journal of Soil Science* **24**, 324–338.

The development of soil classification as a basis for soil mapping is briefly reviewed, and a system for future use is described.

17.22 (Beckett, P. H. T.), Webster, R., (McNeil, G. M. & Mitchell, C. W.) (1972) Terrain evaluation by means of a data bank. *The Geographical Journal* **138**, 430–449.

A data bank is described, to equip engineers and land planners to appraise terrain conditions over wide areas from which existing information is sparse. Terrain classification proposed as indexes to regional data banks and the preliminary results from practical trials of their efficacy are presented.

17.23 Bullock, P., Carroll, D. M. & Jarvis, R. A. (1973) Palaeosol features in northern England. *Nature: Physical Sciences* **242**, 53–54.

17.24 Carroll, D. M. (1972) Air photo interpretation for soil mapping in the Yorkshire Pennines. *The East Midland Geographer* **5**, 296–303.

The value of aerial photography in soil survey was tested in two areas. Many landform and vegetation patterns seen on 1 : 10 560 air photos were related to soil distribution and most boundaries were confirmed by subsequent field checking. Savings of up to 40% of field time are possible for detailed mapping.

17.25 Courtney, F. M. & Webster, R. (1973) A taxonometric study of the Sherborne soil mapping unit. *Transactions of the Institute of British Geographers* No. 58, 113–124.

Sherborne soil has been extensively mapped in the southern Cotswolds. Areas have been re-sampled using a stratified random sampling grid. Fifteen soil variates measured at two pits at each of 92 sites have been used to calculate principal components. By means of filtered scatter diagrams of principal component values, a visual impression has been gained of conceptual variation within the unit. This is compared with the surveyor's original classification and the unit is confirmed as being unimodal.

17.26 Findlay, D. C., (Catt, J. A., Ormerod, E. C., Weir, A. H. & Davies, H.) (1973) A sequence of soils in the Middle Awash Valley, Ethiopia. *African Soils* **18**, 1–18.

17.27 Findlay, D. C., (Hawkins, A. B. & Lloyd, C. R.) (1972) A gravel deposit on Bleadon Hill, Mendip, Somerset. *Proceedings of the University of Bristol Speleological Society* 83–87.

17.28 Hodge, C. A. H., Seale, R. S. & Burton, R. G. O. (1973) Geology and soils. In: *Monks Wood, A Nature Reserve Record*. Ed. R. C. Steele & R. C. Welch. The Nature Conservancy, pp. 4–16.

17.29 Reeve, M. J., Smith, P. D. & Thomasson, A. J. (1973) The effect of density on water retention properties of field soils. *The Journal of Soil Science*, **24**, 355–367.

The bulk density, available water (Av), air capacity (Ca), and retained water capacity (θv) were determined for 158 A, B and C horizons of field soils. Statistical analysis of the results demonstrated that bulk density exerts a profound influence on Av, Ca and θv, but the effect varies between texture groups and horizons. Significant negative correlations were obtained between bulk density and Ca for most textures and horizon groups. In B and C horizons Av and θv also decrease with increasing density, whereas in A horizons they tend to increase, except in silty soils. Within a limited range it is feasible to control these parameters by using field techniques to achieve optimum bulk density for particular soils.

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17.30 RUDEFORTH, C. C. & WEBSTER, R. (1973) Indexing and display of soil survey data by means of feature-cards and Boolean maps. *Geoderma* **9**, 229–248.

A system is described for indexing information from soil survey by punched feature-cards. The information on each record is analysed into a number of simple attributes or 'features' which are then used for indexing. The system has been applied to grid surveys in which sites at intersections of the National Grid are examined. The feature-card grid is oriented so that it represents to scale the National Grid. Each feature-card thus constitutes a map. By carrying out logical operations using the cards in combination, Boolean maps are swiftly derived.

17.31 THOMASSON, A. J. (1973) Factors influencing the water regimes of gleyed clayey soils in moist temperate regions. In: *Pseudogley and gley* Ed. E. Schlichting & U. Schwertmann. *Transactions of Commissions V & VI, International Soil Science Society*. Verlag Chemie., pp. 491–502.

Under temperate climates, slowly permeable clayey soils are subject to waterlogging owing to excess of rainfall over potential transpiration. The degree of waterlogging is a result of interactions between climate, semi-permanent soil properties, land use and ameliorative treatments. Their effect on water regime is best studied in soils with impermeable or slowly permeable horizons within the profile, which are not subject to surface flooding from major streams, do not occur on depressed sites receiving run-off from the immediate environs, do not have a permeable substratum saturated with groundwater and hence are waterlogged primarily as a result of slow disposal of precipitation.

17.32 WEBSTER, R. (1973) Automatic soil-boundary location from transect data. *Mathematical Geology*, **5**, 27–37.

A method is described for determining boundaries automatically on transects. The procedure is illustrated with data from a 6 km transect in Oxfordshire and shows good agreement with boundaries drawn by combined air-photo interpretation and field judgement.

17.33 WEBSTER, R. & (BECKETT, P. H. T.) (1973) Soil and agricultural land classification in Co. Londonderry: a reappraisal. *Transactions of The Institute of British Geographers*, No. 58, 125–128.

The value of the soil map for the agricultural classification of land has been re-appraised. The map has some value for predicting the profitability of all enterprises considered, and for potato growing was very good.

MAPS

17.34 CLAYDEN, B., EVANS, G. D. & WOOD, J. M. (1973) Soil map, 1 : 25 000 Sheet SN 41 (Llangendeirne), Southampton : Ordnance Survey.

17.35 COPE, D. W. (1973) Soil map, 1 : 25 000 Sheet SO 82 (Norton), Southampton: Ordnance Survey.

17.36 FORDHAM, S. J. (1973) Land use capability map, 1 : 25 000 Sheet TR 35 (Deal), Southampton: Ordnance Survey.

17.37 FURNESS, R. R. & KING, S. J. (1973) Soil map, 1 : 25 000 Sheet SJ 37 (Ellesmere Port), Southampton: Ordnance Survey.

17.38 GREEN, R. D. & FORDHAM, S. J. (1973) Soil map, 1 : 25 000 Sheet TR 04 (Ashford), Southampton: Ordnance Survey.

17.39 GREEN, R. D. & FORDHAM, S. J. (1973) Land use capability map, 1 : 25 000 Sheet TR 04 (Ashford), Southampton: Ordnance Survey.

17.40 HARTNUP, R. (1973) Soil map of the Castleford area of Yorkshire, Parts of 1 : 25 000 Sheets SE 31/32/41/42, Southampton: Ordnance Survey.

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17.41 JARVIS, M. G. (HOOPER, L. J. & BATEY, T.) (1973) Land use capability map, 3rd Edition Sheet 253 (Abingdon), 1 : 63 360, Southampton: Ordnance Survey.

17.42 JARVIS, M. G. & JARVIS, R. A. (1973) Soil map. Parts of 1 : 25 000 Sheets SU28/29/38/39 (Faringdon), Harpenden: Rothamsted Experimental Station.

17.43 JARVIS, M. G. & (WALPOLE, R. A.) (1973) Predicted underdrainage treatment for arable land use. 3rd Edition, Sheet 253 (Abingdon), 1 : 63 360, Harpenden: Rothamsted Experimental Station.

17.44 RUDEFORTH, C. C. (1973) Soil map, 1 : 25 000 Sheet SM 90 (Pembroke), Southampton: Ordnance Survey.

17.45 RUDEFORTH, C. C. (1973) Soil map, 1 : 25 000 Sheet SM 91 (Haverfordwest), Southampton: Ordnance Survey.

17.46 SEALE, R. S. (1973) Soil map, 3rd Edition Sheet 173 (Ely), 1 : 63 360, Southampton: Ordnance Survey.

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