ROTHAMSTED RESEARCH

Report for 1964

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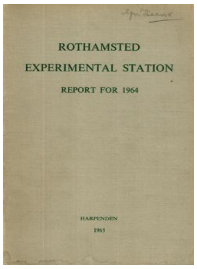

Abstracts of Papers

Rothamsted Research

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ABSTRACTS OF PAPERS

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Physics Department

General Papers

1.1 Monteith, J. L. (1964) Physical parameters of heat balance and evaporation. *Abstracts X int. Bot. Congr., Edinburgh.* No. 567.

1.2 Monteith, J. L. (1964) Physical parameters of photosynthesis in the field. *Abstracts X int. Bot. Congr., Edinburgh.* No. 003.

1.3 Penman, H. L. (1964) Water use by vegetation. *Abstracts X int. Bot. Congr., Edinburgh.* No. 024.

1.4 Penman, H. L. (1964) The mapping of climate. In: *Experimental cartography—Oxford Symposium* 1963. Oxford University Press, pp. 37–40 (Mimeographed).

1.5 Penman, H. L. (1961) Humidity measurement. *Encyclopaedic dictionary of physics.* Oxford: Pergamon Press, **3**, 724.

Research Papers

1.6 Currie, J. A. (1965) Diffusion within soil micro-structure: a structural parameter for soils. *Soil Sci.* (In the press.)

To estimate the diffusion coefficient of gases, D_c, within soil crumbs gaseous diffusion was measured first on a packing of dry 1–2-mm crumbs, then again after the crumb pores, but not the inter-crumb pores, had been rendered non-conducting by saturating with an inert liquid. Using equations for analogous electrical properties of heterogeneous materials, the range of values of D_c/D_o was from 0·025 to 0·156 for eight soils with crumb porosities in the range 0·25–0·41. For each soil, single-value parameters for soil complexity were calculated from D_c/D_o and the appropriate crumb porosity, and these were in accord with known behaviour in the field: the better the structure, the smaller is the complexity parameter. The validity of the method was checked by measuring the diffusion coefficient, D, by standard methods on blocks of soil, and then again by the indirect method on crumbs obtained by crushing the block. Comparison of these values for D and D_c, ideally the same, confirmed the adequacy of the method.

1.7 (Jackson, R. D.), Rose, D. A. & Penman, H. L. (1965) Circulation of water in soil under a temperature gradient. *Nature, Lond.* **205**, 314–316.

When a temperature gradient was applied to a uniform closed soil column a circulatory system was established with a dynamic balance of opposing fluxes of vapour from hot to cold, and liquid from cold to hot, the liquid carrying salt with it. Simple theory shows that simultaneous static equilibrium of temperature, vapour, liquid and solutes cannot occur.

1.8 Long, I. F., Monteith, J. L., Penman, H. L. & Szeicz, G. (1964) The plant and its environment. *Met. Rdsch.* **17**, 97–101.

The climate of the layer of air near the ground is determined by energy transfers and transformations between crop and ground, and between crop and atmosphere. The daily cycle for a barley crop on one sunny day in south-east England is shown in tables and diagrams. The complete energy balance (all quantities in cal/cm²) for the day was: income 491; reflected 117, long-wave radiation 81; net radiation 293; evaporation 291; heating soil 28; *cooling* air 26. Wind

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profiles show the crop as aerodynamically rougher at small wind speeds. Temperature and humidity profiles show steep lapses during early morning calm when dew formed; some of the dew came from the ground. Measured changes in soil water content indicate morning drying of the root layer, partly replenished from below during the afternoon. Carbon dioxide concentration profiles show the soil as a source of carbon dioxide throughout the 24 hours; the atmosphere is a source during daylight, and is a sink at night. Radiation intensities in the crop vary with depth, and time of day. The main interception—as expected—is in the thickest part of the canopy: below the main canopy about 40% of the total radiation, and 25% of the visible radiation is transmitted towards the soil surface.

1.9 MONTEITH, J. L. (1965) Evaporation and environment. *Symp. Soc. exp. Biol. XIX.* (In the press.)

Starting from the thermodynamics of moist air, the formulae of Penman and of Slatyer and McIlroy are derived to estimate the rate of evaporation from an open water surface and of transpiration from an isolated leaf. In given weather transpiration rate depends on an external diffusive resistance r_a, a function of leaf size, shape and wind speed; and an internal resistance r_e determined mainly by the size and number of stomata. For the leaves of crop plants with stomata wide open, r_a is about 0·05–0·1 sec cm^{-1} and r_e is about 1–2 sec cm^{-1}. Transpiration rates are governed by stomatal aperture and are almost independent of wind speed. When similar analysis is applied to the complete canopy of a crop r_a is about 0·2–0·5 sec cm^{-1} at wind speeds between 1 and 5 m sec^{-1}, and the analogue of leaf resistance is a surface resistance r_s, about 0·3–0·5 sec cm^{-1}. The ratio of actual transpiration E to the evaporation from the same crop with wet leaves E_o depends on r_s/r_a and ranges from $E/E_o \simeq 1$ for irrigated short grass ($r_s/r_a \simeq 0{\cdot}2$) to $E/E_o = 0{\cdot}2$ for pine forest ($r_s/r_a \simeq 15$). When $r_s/r_a \simeq 1$, $E/E_o \simeq 0{\cdot}8$. Values of r_s and r_a are presented for a range of crops and climates, and the fraction of net heat used for transpiration ($\lambda E/H$) is found to be well correlated with r_s. Further analysis establishes a critical stomatal resistance at which the transpiration rate is independent of wind speed.

The attenuation of visible light within a canopy is the most important feature of microclimate determining total transpiration from a crop. Transpiration increases with leaf area up to a maximum area beyond which the lowest leaves are so shaded that stomata are closed. The annual transpiration for short grass, a tall crop, and a pine forest are calculated for the Thames Valley, England (48 $\pm$ 10 cm), and for the Sacramento Valley, California (168 $\pm$ 20 cm). For the complete range of crops and climates, $\lambda E/H$ ranges from 0·7 to 1·2. Larger values of $\lambda E/H$ are reported from sites where an irrigated crop is surrounded by dry land, but theoretical analyses of the effects of advection do not allow for the important restriction of transpiration by stomatal closure.

1.10 MONTEITH, J. L. (1965) Light distribution and photosynthesis in field crops. *Ann. Bot.* **29**, 17–37.

In a new model of light distribution in field crops, a parameter s is the fraction of light passing through unit leaf layer without interception. Radiation profiles measured with solarimeters and photocells give values of s from 0·7 for grasses to 0·4 for species with prostrate leaves. Knowing s, leaf transmission τ and leaf area index L, the light distribution in a field crop may be described by a binomial expansion of the form $\{s + (1 - s)\tau\}^L$. To calculate crop photosynthesis at given light intensity, this expansion is combined with two parameters describing the shape of the light-response curve of single leaves. Finally, the assumption that

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solar radiation varies sinusoidally allows daily total photosynthesis to be estimated from daylength and insolation.

The theory predicts about the same potential photosynthesis in a cloudy temperate climate with long days and in a more sunny equatorial climate with short days. When $L < 3$, photosynthesis increases as *s decreases*, i.e., as leaves become more prostrate; but when $L > 5$, photosynthesis increases as *s increases*, i.e., as leaves become more erect. Assuming that respiration is proportional to leaf area, estimated dry-matter production agrees well with field measurements on sugar beet, sugar cane, kale and subterranean clover. Estimates of maximum gross photosynthesis (for sugar cane and maize) range from 60 to 90 g m^{-2} day^{-1}, depending on insolation.

1.11 MONTEITH, J. L., SZEICZ, G. & (YABUKI, K.) (1964) Crop photosynthesis and the flux of carbon dioxide below the canopy. *J. appl. Ecol.* **1** 321–337.

The upward flux of carbon dioxide at the soil surface was calculated from the weight increase of soda-lime granules exposed inside a glass tank covering 400 cm^2 soil. Over bare soil the flux varied annually, with a summer maximum of about 7 g CO_2 m^{-2} day^{-1}, a winter minimum of 1 g m^{-2} day^{-1} and a Q_{10} of 3. From the difference of flux over fallow and cropped soil the contribution of root respiration was usually about 1–3 g m^{-2} day^{-1}.

From dry-matter determinations the amount of soil carbon assimilated by crops was about 6% of the net carbon uptake for rapidly growing grass in spring and about 20% for other crops during the summer. The top 46 cm of the soil profile contained 12 kg carbon m^{-2} and lost 0·4 kg m^{-2} annually by respiration. The corresponding half-life of soil organic matter is 22 years.

The variation of carbon dioxide concentration and rate of photosynthesis with soil flux depends on wind speed and atmospheric stability. In most weather atmospheric mixing is so vigorous that the concentration in the canopy and the free atmosphere are very similar (*ca* 300 ppm) and photosynthesis is independent of soil flux. In glasshouses where mixing is suppressed the concentration may be much less than 300 ppm, and for chosen conditions gross photosynthesis increased by 30% when the upward flux of carbon dioxide below the canopy increased by 10 g m^{-2} day^{-1} (4 lb $acre^{-1}$ h^{-1}).

1.12 ROSE, D. A. (1965) Water movement in unsaturated porous materials. *RILEM Bull.* No. 28. (In the press.)

A theory of isothermal water movement in the vapour and liquid phases is presented. Vapour movement in unsaturated porous materials was estimated from hydrogen diffusion measurements, and total water movement from the diffusion of water vapour, enabling the liquid contribution to flow to be found by difference. For each of two building stones and four soils the proportion of water movement as vapour falls rapidly as the moisture content increases. The interaction of a vapour flux with the liquid in unsaturated materials is discussed, and six stages in the wetting of a porous system, together with their associated flow régimes, are identified.

1.13 SZEICZ, G. (1965) A miniature tube solarimeter. *J. appl. Ecol.* **2**. (In the press.)

Details are given for making a cheap robust radiometer suitable for use within the canopies of crops only a few inches tall.

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Chemistry Department

Books

2.1 Benzian, B. (1965) Experiments on nutrition problems in forest nurseries. *Bull. For. Commn, Lond.* No. 37 (in two volumes). Vol 1. Text, summary-tables, diagrams, colour supplement; with contributions by Brind, J. E., Goodey, J. B., Griffin, D. M. and Levisohn, I.; Vol II. Supporting tables. Vol I, ix, 251 pp; Vol II, vi, 265 pp.

2.2 Cooke, G. W. (1964) *Fertilizers and profitable farming.* 2nd edition. London: Crosby Lockwood, xix, 143 pp.

Theses

2.3 Bolton, J. (1964) A study of the leaching of commonly used fertilisers on Malayan latosols used for the cultivation of *Hevea brasiliensis.* M.Sc. Thesis, University of Leeds.

2.4 Hoyt, P. B. (1964) The decomposition of plant chlorophyll and its derivatives in soil. Ph.D. Thesis, University of London.

General Papers

2.5 Benzian, B. (1964) Nutrition experiments in forest nurseries. *Rep. For. Res., Lond.* for 1963, pp. 87–88.

2.6 Bolton, J. (1964) The manuring and cultivation of *Hevea brasiliensis. J. Sci. Fd Agric.* **15**, 1–8.

2.7 Cooke, G. W. (1964) Soils and fertilisers. *Jl. R. agric. Soc.* **125**, 142–169.

2.8 Cooke, G. W. (1963) General principles governing the potassium manuring of grassland. *Proceedings of the First Regional Conference of the International Potash Institute, Wexford*, pp. 71–82.

2.9 Cooke, G. W. (1964) What about liquids? *Dairy Fmr, Ipswich*, March 1964, 53–55.

2.10 Cooke, G. W. (1964) The basis of modern manuring. *Devon County Agricultural Association Lecture; Seale-Hayne Agricultural College*, 27 pp.

2.11 Cooke, G. W. (1964) Nitrogen fertilisers: their place in food production, the forms which are made and their efficiencies. *Proc. Fertil. Soc.* No. 80, 88 pp.

2.12 Cooke, G. W. (1964) Acceptance of optimum dressings can be misleading. *Fmg Wld* 27 August, No. 257, p. XIX.

2.13 Coulter, J. K. (1964) Soil surveys and their application in tropical agriculture. *Trop. Agriculture, Trin.* **41**, 185–196.

2.14 Gasser, J. K. R. (1964) Urea as a fertiliser. *Soils & Fert.* **27**, 175–180.

2.15 Gasser, J. K. R. (1964) Fertiliser urea. *World Crops*, March, **16**, 25–32.

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2.16 MATTINGLY, G. E. G. (1963) Farm crops. *Rep. Progr. appl. Chem.* **48**, 407–418.

2.17 NOWAKOWSKI, T. Z. (1964) Mineral fertilisation and organic composition of herbage. *Proceedings of the Second Regional Conference of the International Potash Institute, Morat, Switzerland*, "Le potassium et la qualité des produits agricoles". pp. 63–73.

2.18 SALMON, R. C. (1963) Magnesium relationships in soils and plants. *J. Sci. Fd Agric.* **14**, 605–610.

2.19 TALIBUDEEN, O. (1964) Soils. *Rep. Progr. appl. Chem.* **49**, 395–406.

2.20 TALIBUDEEN, O. (1964) Natural radioactivity in soils. *Soils & Fert.* **27**, 347–359.

RESEARCH PAPERS

2.21 BOLTON, J. (1964) The response of immature *Hevea brasiliensis* to fertilisers in Malaya. I. Experiments on shale derived soils. *J. Rubb. Res. Inst. Malaya* **18**, 67–79.

A report on three fertiliser experiments from the time of planting to maturity when the trees were tapped.

2.22 CUNNINGHAM, R. K. (1964) Micro-nutrient deficiency in cacao in Ghana. *Emp. J. exp. Agric.* **32**, 42–50.

Cacao showing symptoms of both iron and zinc deficiency, and containing little manganese, yielded less than half as much as symptomless trees. Chlorotic leaves contained more iron than healthy leaves. Zinc deficiency symptoms showed when Zn in leaves was less than 15 ppm. Whether small concentrations of manganese in leaves affected yield is not certain, but cacao tolerates a wide range of manganese concentrations without showing symptoms.

Plants lacked iron, zinc and manganese because soil pH was above 7·6. Zinc deficiency was remedied by lowering soil pH, which also increased manganese concentrations in the trees, but only foliar spraying with iron corrected iron chlorosis. Foliar sprays of micro-nutrients included in insecticidal sprays are probably the easiest and cheapest ways of correcting deficiencies. Although micro-nutrient deficiencies are not widespread in Ghana when cacao is grown under forest, they could be serious where cacao is planted on newly cleared land.

2.23 CUNNINGHAM, R. K. (1964) Cation–anion relationships in crop nutrition. I. Factors affecting cations in Italian ryegrass. *J. agric. Sci., Camb.* **63**, 97–101.

Tests of more than 100 Italian ryegrass samples showed the content of Σ cations (Na + K + Ca + Mg in m-equiv./100 g dry matter) is not constant, and factors causing them to vary were investigated. The sums of the cations in ryegrass ranged from 80 to 205 m-equiv./100 g dry matter, so cation antagonisms are unlikely to occur because Σ cations remain constant within plants. However, Σ cations were positively correlated with Σ anions (N + P + Cl + S in m-equiv./100 g dry matter) and with % N in the grass, and Σ cations and Σ anions were better correlated when Si was omitted; Si probably does not enter the plant as an ion. The relationship between Σ cations and Σ anions or % N depended on the form of N (NH_4-N or NO_3-N) taken up by the grass; they were also influenced by large uptakes of Na and Cl.

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2.24 CUNNINGHAM, R. K. (1964) Cation–anion relationships in crop nutrition. II. Factors affecting the ratios of sum of the cations : sum of the anions in Italian ryegrass. *J. agric. Sci., Camb.* **63**, 103–108.

The ratios of Σ cations (Na + K + Ca + Mg in m-equiv./100 g): Σ anions (N + P + Cl + S in m-equiv./100 g), *R* values, in over 100 samples of Italian ryegrass grown in the field ranged from 0·33 to 0·92. Italian ryegrass, grown in the glasshouse at 11 levels of a nutrient mixture, had *R* values ranging from 0·58 to 1·36. The *R* values of Italian ryegrass grown in the field and in the glasshouse were negatively correlated with % N in the grass and depended on the form of nitrogen (NH_4-N or NO_3-N) taken up by the grass, but there was no relationship between *R* and % K in the ryegrass. The curve showing the relationship between *R* and % N for grass in the glasshouse did not coincide with that of samples grown in the field. Trace elements were excluded from calculations of *R* values because they contributed little to Σ cations or Σ anions. Although the ratio of Σ cations : Σ anions did not measure the internal ionic balance of the plants, *R* values and their relationships with % N were useful for explaining ion interactions, antagonisms and synergisms in crop nutrition. A plant mechanism is suggested that regulates the proportion of Σ cations and Σ anions taken up by the plants from the soil solution; this mechanism may be linked with nitrogen metabolism.

2.25 CUNNINGHAM, R. K. (1964) Cation–anion relationships in crop nutrition. III. Relationships between the ratios of sum of the cations : sum of the anions and nitrogen concentrations in several plant species. *J. agric. Sci., Camb.* **63**, 109–111.

The ratios of sum of the cations : sum of the anions (*R*) of 62 agricultural and horticultural crops and pasture herbs were measured or calculated and found to be negatively correlated with % N in the plants. This suggests that the proposal that Italian ryegrass has a mechanism regulating the proportion of cations to anions taken up may also apply to other plant species. Dicotyledons had greater *R* values than monocotyledons at the same N level, but this is probably not because their roots have greater cation exchange capacity.

2.26 GASSER, J. K. R. & PEACHEY, J. E. (1964) A note on the effects of some soil sterilants on the mineralisation and nitrification of soil-nitrogen. *J. Sci. Fd Agric.* **15**, 142–146.

Dazomet, "D-D", metham-sodium and methyl isothiocyanate were applied to seven glasshouse and four field soils; methyl bromide was applied to two of the field soils. In both the glasshouse and field all sterilants retarded nitrification of ammonium-N, and in some soils they increased the mineralisation of soil organic-N; dazomet had most effect and metham-sodium least. In field soils methyl bromide increased the mineralisation of soil organic-N more than the other sterilants.

2.27 GASSER, J. K. R. & JEPHCOTT, B. M. (1964) Soil nitrogen. VIII. Some factors affecting correlations between measurements of soil-N status and crop performance. *J. Sci. Fd Agric.* **15**, 422–428.

In 1959 samples of 17 soils from sites of experiments testing N fertilisers with barley were used to measure their N status in the laboratory, and 14 of the soils were used to grow ryegrass in pots. In the fresh soils nitrate-N and mineral-N (ammonium-N + nitrate-N) were measured, and also the increases on incubating the fresh or re-wetted air-dry soil (Δ nitrate-$N_{fresh\ or\ air\text{–}dry}$ and Δ mineral-$N_{fresh\ or\ air\text{–}dry}$).

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These measurements and similar ones obtained in 1958 were correlated with yields of barley grown without fertiliser-N and with the grain response to 0·5 cwt of N/acre as fertiliser.

The laboratory measurements showed that mineralisable-N increased more by drying soils at 25° than at 15–18°, and the values determined after storing for 32 weeks before incubating correlated slightly less well with crop performance than values after 12 weeks of storage. Yields of ryegrass and its content of N were correlated better with nitrate-N than with mineral-N in fresh soils.

Mineral-N_{fresh} and Δ mineral-$N_{air-dry}$ were correlated most consistently with the yield of barley grain from unfertilised soils or its response to fertiliser-N. With measurements on fresh soils, nitrate-N correlated better than mineral-N with crop performance; with air-dry soils, Δ mineral-N correlated better than Δ nitrate-N. The slopes of the lines for the regressions of responses of barley on soil-N varied between years.

2.28 GASSER, J. K. R. (1964) Effects of solutions of urea and of ammonium and potassium salts on the germination of kale, barley and wheat. *Chemy Ind.* 1687–1689.

Urea in solution decreased the germination of kale, barley and wheat. Increasing concentrations of ammonium and potassium salts decreased the germination of kale more than of barley, and barley more than wheat. When germination was decreased, ammonium salts were more damaging than potassium ones. Sulphate was less damaging than nitrate or chloride.

2.29 GASSER, J. K. R. (1964) Some factors affecting losses of ammonia from urea and ammonium sulphate applied to soils. *J. Soil Sci.* **15**, 258–272.

Urea supplying 100 lb of N/acre was either broadcast on the surface or mixed with four soils (two clay-loams, two sandy-loams), and losses of ammonia were measured when the soils were maintained at 40, 50 or 60% water-holding capacity (WHC) and incubated at 5° or 25° C. Urea and ammonium sulphate were similarly applied to two calcareous soils at 40% WHC and 5° or 25° C. Losses varied most among soils, from 2% of the N applied from an unmanured clay-loam to 13% from an unmanured sandy-loam. Changing temperature and water content affected losses little on average, but their effects differed with different soils. Losses of ammonia were similar from urea and from ammonium sulphate applied to the calcareous soils. Analyses at the end of the experiments showed that: (i) nitrite accumulated in the sandy and calcareous soils, particularly in cold wet soil; (ii) ammonia was lost at 25° C from calcareous soils until all the ammonium-N had been nitrified, from the slightly alkaline clay soils until nine-tenths had been nitrified and from the neutral sandy soils until half had been nitrified.

2.30 (MOSS, P.) & COULTER, J. K. (1964) The potassium status of West Indian volcanic soils. *J. Soil Sci.* **15**, 284–298.

The potassium status of a group of unfertilised volcanic soils was measured by the intensity, exchangeable, nitric acid-soluble, fixation and total potassium values. The soils were classified by the amount of weathering and predominant clay minerals as determined by field characteristics. The soils containing principally pyroxenes, soda-lime feldspars, and variable quantities of glass and amphiboles. The fine-sand fraction was free from potassium-bearing minerals. Clay content ranged from 5 to 72%, and total potassium averaged 0·38%. Neither potassium readily soluble in nitric acid nor the difficultly soluble potassium were related to percentage clay, but both were highly correlated with total potassium. Little potassium was fixed. Potassium intensity, expressed by pK-

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½p(Ca + Mg) values, was determined by equilibrating soil with potassium in calcium chloride solutions. The values were similar to those from soil-solution extracts displaced by alcohol. The potassium-intensity status was greatest in allophane soils and least in montmorillonite soils; it was correlated with exchangeable K, fixed K and with K readily soluble in nitric acid. The last was highly correlated with exchangeable potassium. Partial correlation coefficients showed that the major factors controlling potassium intensity were exchangeable potassium relative to exchangeable calcium and magnesium and the potassium-fixing ability.

2.31 NIELSEN, K. F. & CUNNINGHAM, R. K. (1964) The effects of soil temperature and form and level of nitrogen on growth and chemical composition of Italian ryegrass. *Proc. Soil Sci. Soc. Am.* **28**, 213–218.

Italian ryegrass was grown in a clay loam soil in a glasshouse at three soil temperatures 11°, 19·5° and 28° C with 6 levels of N (0–500 ppm) as NH_4^+ (treated with "N-Serve") or NO_3^-. Tops grew best at 19·5° and roots at 11° C. At 19·5° yields of tops with NO_3-N were maximal at 100 ppm and with NH_4-N at 200 ppm. Increasing NO_3-N above 100 ppm greatly decreased yields of tops, but increasing NH_4-N did not. Tops yielded more with NO_3-N than with NH_4-N with small amounts of N but less with larger amounts.

Root weights were similar with both forms of N, but with NH_4-N roots were well distributed through the soil, whereas with NO_3-N they were mostly in the top half of the soil.

Form of N greatly influenced the composition of the grass. Increasing NO_3-N decreased the concentrations of P, Cl and S, and NH_4-N decreased the concentrations of Ca. Per cent N was larger with NO_3-N than with NH_4-N.

Raising the soil temperature greatly increased % Ca and % Mg, but had little influence on concentrations of N, P, S, Na and K. Per cent Cl was always largest at 11° C.

2.32 NOWAKOWSKI, T. Z., CUNNINGHAM, R. K. & NIELSEN, K. F. (1965) Nitrogen fractions and soluble carbohydrates in Italian ryegrass. I. Effects of soil temperature, form and level of nitrogen. *J. Sci. Fd Agric.* **16**, 124–134.

Analysis of the S 22 Italian ryegrass described in the previous paper (No. 2.31) showed much more total N, total soluble-N and nitrate-N and less protein-N, amide-N (particularly asparagine) and α-amino-N in grass given NO_3-N than in grass given NH_4-N. These differences increased with increasing amounts of applied N. Increasing soil temperature considerably increased the total soluble-N and decreased the protein-N, irrespective of the form of N added. With all treatments, plants contained very little soluble carbohydrates; at 11° soluble carbohydrates decreased with increasing level of N, more with NH_4-N than NO_3-N. The causes of nitrate accumulation in grass are discussed.

2.33 SALMON, R. C. & ARNOLD, P. W. (1963) The uptake of magnesium under exhaustive cropping. *J. agric. Sci., Camb.* **61**, 421–425.

A range of soils were cropped exhaustively by perennial ryegrass for up to 11 months in the glasshouse; some were also cropped with Dutch white clover.

At least 100 lb/acre of magnesium was taken up from most soils, and some soils supplied more than 200 lb/acre. The amounts of magnesium taken up decreased with successive harvests, suggesting that the available magnesium was progressively depleted. Although the "exhaustion" magnesium (Mg taken up by crops + residual exchangeable magnesium) was greater than the initial exchangeable magnesium, these two measurements were closely correlated (r =

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0·99). If non-exchangeable magnesium was released during cropping the releases were proportional to the initial exchangeable magnesium contents. However, the exchangeable magnesium measurements may have extracted only a proportion of the magnesium available naturally.

Any releases of magnesium were small compared with the amounts available from the outset, and the crops obtained magnesium mainly from the exchangeable form. Ryegrass and white clover gave similar results.

The exchangeable magnesium in some exhausted soils was increased by wetting and drying. This effect may occur in the field, where the magnesium lost in cropping could be replenished by only small releases of non-exchangeable magnesium.

2.34 SALMON, R. C. (1964) Cation exchange reactions. *J. Soil Sci.* **15**, 273–283.

Wyoming bentonite, Blisworth illite and a fen peat were saturated with different proportions of calcium, magnesium and potassium, and exchange between these cations was studied by measuring their activity ratios in dilute equilibrium solutions. With both clays the activity ratio a_{Mg}/a_{Ca} in solution was linearly related to the ratio of adsorbed Mg/Ca; the first was 1·22 times larger than the second. Peat held magnesium much less strongly than calcium, and the difference increased with increasing magnesium saturation. With all three materials the activity ratio a_{Mg}/a_{Ca+Mg} in solution was curvilinearly related to the percentage magnesium saturation. Peat adsorbed potassium less strongly relative to the divalent cations than did the clays, and bentonite adsorbed potassium less strongly than illite. Decreasing the Ca : Mg ratio increased the strength with which peat adsorbed potassium, but had no effect on potassium adsorption by the clays. Exchange between magnesium and calcium in 40 British soils was studied by measuring the concentration ratio [Mg]/[Ca + Mg] in equilibrium soil solutions. The relation between [Mg]/[Ca + Mg] in solution and the ratio of exchangeable Mg/[Ca + Mg] in different soils varied within the range covered by peat and bentonite or illite, suggesting that differences between soils may depend on organic-matter contents. The extent to which [Mg]/[Ca + Mg] in solution was altered by changes in the exchangeable magnesium content differed considerably between soils. These differences were not all explained by variations in exchange capacity, showing that different soils adsorb magnesium with differing strengths relative to calcium.

2.35 SALMON, R. C. (1964) Cation-activity ratios in equilibrium soil solutions and the availability of magnesium. *Soil Sci.* **98**, 213–221.

Perennial ryegrass was grown on two soil types, each with four exchangeable K contents and Ca : Mg ratios. At constant K the Mg concentration in grass was linearly related to ion activity ratios in the equilibrium soil solutions, so Mg in grass was doubled only when the exchangeable Mg was quadrupled. Increasing K decreased the Mg in grass.

On cropping a range of soils with different exchangeable Mg, Ca, K and soil pH, the Mg concentration in grass was poorly correlated with exchangeable Mg and with simple ion activity ratios. An expression was developed which was closely correlated with Mg uptake.

2.36 SALT, P. D. (1965) An apparatus for measuring losses of ammonia from decomposing plant materials. *Chemy Ind.* 461–462.

The laboratory method and apparatus described was devised to see whether nitrogen (as ammonia) was lost from decomposing plant materials exposed to a

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current of moist air. From a quarter to one-third of the total nitrogen in the grass clippings used was lost.

2.37 TALIBUDEEN, O. & ARAMBARRI, P. (1964) The influence of the amount and the origin of calcium carbonates on the isotopically exchangeable phosphate in calcareous soils. *J. agric. Sci., Camb.* **62**, 93–97.

The kinetics of the isotopic exchange of phosphate ions in soils with and without phosphate added in the laboratory were examined in relation to the amount and origin of the $CaCO_3$ they contained. The isotopic exchange index, "P_r/P_e", and the recovery of added phosphate were inversely proportional to carbonate content in soils containing carbonates of similar geological origin; soils from the Lower Lias showed the biggest change in P_r/P_e with carbonate content.

In soils from the Cretaceous Chalk the first-order rate of isotopic exchange of the "slow" phosphate fraction was constant. It increased to a larger but constant value in the soils incubated for 6 months after adding phosphate in the laboratory. This rate constant is therefore specific to the calcium phosphates in a group of soils derived from the same calcareous parent material and with similar phosphate manuring.

A method using ^{45}Ca as a radio-tracer was developed and used to measure the specific surface of $CaCO_3$ in soil.

The "slow" rate constants for calcareous soils derived from different parent materials, but containing similar amounts of $CaCO_3$, were inversely proportional to the specific surfaces of their $CaCO_3$. The "P_r/P_e" index and the recovery of 10 mg P added as $Ca(H_2PO_4)_2$/100 g soil were also inversely related to the specific surfaces of the $CaCO_3$.

2.38 WIDDOWSON, F. V. & PENNY, A. (1964) Experiments comparing liquid and solid fertilisers for grass and kale. *Expl Husb.* No. 10, 97–100.

Two experiments compared yields of Italian ryegrass from a liquid fertiliser (containing 20% N) with those from solid urea at rates supplying 20, 40, 60, 80 or 100 units N/acre per cut. In each year and at each cut solid N gave slightly more grass than did liquid N.

Two experiments compared yields of kale from a liquid compound fertiliser (14% N, 6% P_2O_5, 8% K_2O) with yields from solid fertilisers supplying equivalent plant nutrients (as urea, superphosphate and muriate of potash). Each fertiliser was applied, either over the seedbed or over the kale leaves in July, at rates supplying 100 or 200 units N/acre (plus P and K). Yields were greater with solid NPK than with liquid NPK fertiliser in each year and at each time of application.

2.39 WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1964) Experiments testing P and K fertilisers on lucerne (1952–57). *Expl Husb.* No. 10, 39–45.

From 1952 to 1954 a lucerne experiment compared responses to "starter" P (40 units P_2O_5/acre) with responses to broadcast and to ploughed-down P (100 units P_2O_5/acre). Broadcast and ploughed-down K dressings were also compared. Early establishment and yield were best when "starter" P was given, and small benefits persisted into 1954; when "starter" P was given no further P was needed. Yields were largest with "starter" P plus broadcast K. Ploughed-down and broadcast P behaved similarly, as did ploughed-down and broadcast K. Maximum P uptake (50 lb P/acre) was similar to, and maximum K uptake (250 lb K/acre) much greater than, the P and K fertiliser applied.

From 1955 to 1957, in a second lucerne experiment, yields from single seedbed dressings of K applied in 1955 were greater than yields from equivalent dressings

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divided equally between 1955, 1956 and 1957. The maximum increase was 11·1%. Maximum K applied (279 lb K/acre) and maximum K uptake (264 lb K/acre) were similar.

2.40 WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1964) An experiment comparing responses to nitrogen fertiliser of four grass species. Part II. Residual effects in wheat and barley. *Expl Husb.* No. 11, 22–30.

Pure swards of cocksfoot (S.37), meadow fescue (S.215), ryegrass (S.24) and timothy (Scotia), grown without N or with 30 or 60 units N/acre per cut from 1958 to 1960, were ploughed in September 1960, and followed in 1961 by spring wheat given 0, 100, 200 or 300 units K_2O/acre (whole plots), and 0, 50 or 100 units N/acre (sub-plots). Wheat (grain and straw) yielded more after meadow fescue or ryegrass than after cocksfoot or timothy leys; N applied to the leys decreased these differences, but N applied to the wheat did not. N applied to the leys increased wheat yields, more so after cocksfoot or timothy than after meadow fescue or ryegrass. N to wheat increased yield greatly and similarly after each grass, but K to the wheat increased yields only after meadow fescue or ryegrass.

In 1962 spring barley tested 0, 30, 60 or 90 units N/acre after each grass. Barley yields after leys not given N were greatest after meadow fescue or ryegrass, but all yields after leys given N were similar; applying N to barley did not affect these comparisons. N applied to the leys increased barley yields, but only after cocksfoot or timothy. The amounts of N and K taken up by wheat were well correlated with yields and responses to N and K fertiliser.

Total soil N after each grass (grown without N) and wheat yields were not correlated, but mineralisable soil N and wheat yields were. In September 1960 total N and mineralisable soil N were increased by the N applied to the grasses, but in March 1962 mineralisable soil N was not.

2.41 WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1964) Side-placing urea and other nitrogen fertilisers for spring barley. *J. agric. Sci., Camb.* **62**, 73–82.

Laboratory experiments compared alternative ways of placing urea for wheat. Urea greatly increased the pH in the seed-row; placed in contact with seeds, it killed many plants, but did not when placed 1 in. to the side of the seed.

A combine-drill was modified so that, by simple adjustments, fertilisers could be placed in contact with the seed, or at 1 in. to the side of the seed, or broadcast over the seedbed.

Fifteen experiments with spring barley and one with spring wheat, made from 1960 to 1962, compared yields from urea with yields from ammonium sulphate; calcium nitrate and sodium nitrate were tested in seven and in six experiments, respectively. Each fertiliser was compared broadcast over the seedbed, combine-drilled or placed 1 in. to the side of the seed, at 0·35 or 0·70 cwt N/acre. Eleven experiments were on soils that contained much calcium carbonate and five on other soils.

Urea and ammonium sulphate gave similar yields when broadcast. When combine-drilled, urea but not ammonium sulphate killed some plants and decreased yield. Urea placed 1 in. to the side of the seed was safer and gave larger yields than side-placed ammonium sulphate. Urea and ammonium sulphate yielded similarly on soils with much calcium carbonate, so both fertilisers probably lost similar amounts of free ammonia.

Calcium nitrate and sodium nitrate gave larger yields than ammonium sulphate when broadcast, but only slightly larger yields when combine-drilled or side-placed. In two experiments in 1962 sodium nitrate gave considerably more grain than did ammonium sulphate.

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The experiments were on fields where cereals had been grown often; 0·70 cwt N/acre was fully justified.

Each year the mean nitrogen content of barley grain from plots without fertiliser N was rather more than 1·6%. Ammonium sulphate increased grain percentage N and N uptake least, so it was the least efficient N fertiliser on these soils. At 0·70 cwt N/acre most N was recovered from calcium or from sodium nitrate.

Pedology Department

General Paper

3.1 Bloomfield, C. (1964) Mobilisation and immobilisation phenomena in soils. Problems in Palaeoclimatology. Ed. Nairn. Interscience. 661–665.

Research Papers

3.2 Greene-Kelly, R. & (Derjaguin, B. V.) (1963) Double refraction of thin liquid films. *Doklady Akad. Nauk. S.S.S.R.* **153**, 638–641.

Thin water films in oriented Na-montomorillonite aggregates and some organic films were shown to have double refraction. (In Russian.)

3.3 Greene-Kelly, R. (1964) The specific surface areas of montmorillonites. *Clay Min. Bull.* **5**, 392–400.

The specific surface areas of three montmorillonite samples, both alone and in admixture with kaolinite, were measured. The results are discussed in relation to the possible existence of montmorillonite crystals.

3.4 Jenkinson, D. S. (1965) The decomposition of labelled plant material in soil. In: *Experimental Pedology. The proceedings of the eleventh Easter School in Agricultural Science, University of Nottingham*, 1964. Butterworths, London, 1965. (In the press.)

Ryegrass uniformly labelled with carbon-14 was incubated with a range of soils for one year in the field. The soils differed in mechanical composition, pH and in organic content. About one-third of the labelled ryegrass carbon was retained by all soils except two very acid ones (pH 3·7) which retained about 40% of the added carbon. This suggests that except for very acid soils it is the chemistry of the plant residue that determines its stability, not the nature of the soil in which it is decomposing. In these experiments the soil was kept bare; in a subsidiary experiment ryegrass roots lost more carbon when the soil was kept bare than when grass was grown on it.

Soil Microbiology Department

General Paper

4·1 Skinner, F. A. (1965) The enrichment and isolation of anaerobic cellulolytic soil bacteria. *Zentrbl. für Bakt.* (In the press.)

Research Papers

4.2 (Claus, D.) & Walker, N. (1964) The decomposition of toluene by soil bacteria. *J. gen. Microbiol.* **36**, 107–122.

Strains of two bacteria, a Pseudomonas and an Achromobacter, which grow with toluene, benzene or certain other related aromatic compounds as sole carbon

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source were isolated from soil. The use of aromatic compounds by these bacteria is an induced phenomenon. Toluene-grown organisms oxidise without lag toluene, benzene, catechol, 3-methyl-catechol, benzyl alcohol and, more slowly, *o*- and *m*-cresol, but not benzaldehyde or benzoic acid. 3-Methyl-catechol, acetic acid, pyruvic acid and a yellow ether-soluble acidic substance which is colourless in acid solution were detected in toluene-oxidising cultures. Acetic and pyruvic acids are also formed during the bacterial oxidation of 3-methylcatechol. 3-Methylcatechol is probably an early stage in the bacterial metabolism of toluene; benzaldehyde and benzoic acid seem not to be intermediates in this metabolism.

4.3 GREGORY, P. H., FESTENSTEIN, G. N., LACEY, M. E., SKINNER, F. A. (PEPYS, J. & JENKINS, P. A.) (1964) Farmer's lung disease: the development of antigens in moulding hay. *J. gen. Microbiol.* **36**, 429–439.

For summary, see No. 7.19.

4.4 KLECZKOWSKI, J. & KLECZKOWSKI, A. (1965) Inactivation of a Rhizobium bacteriophage by ultraviolet radiation of different wavelengths. *Photochem. Photobiol.* **4**. (In the press.)

The action spectrum for inactivation of a *Rhizobium* bacteriophage by UV radiation follows the shape of the absorption spectrum of DNA between the wavelengths of 240 and 290 mμ (where inactivation probably reflects damage to the nucleic acid only), and deviates sharply upwards at wavelengths shorter than 240 mμ (where inactivation may depend on damage to both the phage nucleic acid and protein). The rate of inactivation follows first-order kinetics approximately at all wavelengths tested. Infectivity of the phage is halved when each mg of the phage nucleic acid has absorbed about 0·08 joule of radiation energy at any wavelength between 240 and 290 mμ.

The bacteriophage can be photoreactivated after inactivation at any wave length between 230 and 290 mμ, but less so after inactivation at 230 mμ than at any wavelength above 240 mμ.

No evidence was found to suggest that dimerisation of thymine residues of the phage-DNA plays any part in the mechanism of inactivation of the bacteriophage by UV radiation.

4.5 WALKER, N. (1964) Decomposition of β-Naphthol by a soil Pseudomonad. *J. appl. Bact.* **27**, 265–372.

A pseudomonad resembling *Pseudomonas fluorescens*, which grows with β-naphthol as sole source of carbon, was isolated from soil. Phenol, benzoic acid, *o*-, *p*- and (to a small extent) *m*-hydroxybenzoic acid support growth of the organism, but it does not grow on either naphthalene, α-naphthol, 1,2- or 2,3-dihydroxynaphthalene. A maroon-coloured substance was produced from β-naphthol in cultures and by washed organisms. β-Naphthol oxidation depends on an induced enzyme system. β-Naphthol-grown organisms oxidise β-naphthol and 2,3- and 2,6-dihydroxynaphthalene immediately and several mono- and dihydroxybenzoic acids, including salicylic acid, only after a lag. 2,3-Dihydroxynaphthalene may be a metabolite of β-naphthol, but of this there remains some doubt.

Botany Department

GENERAL PAPER

5.1 THURSTON, J. M. (1964) The biological basis of the control of wild oats. *N.A.A.S. q. Rev.* **65**, 22–28.

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Research Papers

5.2 Humphries, E. C. & French, S. A. W. (1964) Determination of leaf area by rating in comparison with geometric shapes. *Ann. appl. Biol.* **54**, 281–284.

The accuracy of the rating method of determining leaf area by using geometric shapes, viz., circles, squares and ellipses, in preference to facsimile leaf shapes was studied. The standards were arranged in geometric or arithmetic series. Ellipses gave a worse estimate of area than squares or circles. Shapes arranged in a geometric series underestimated true area, whereas those in arithmetic series overestimated it. The geometric series had a smaller deviation, but the previous preference for a geometric series, based on theoretical considerations, seems unjustified. The mean leaf area of six sugar-beet and potato plants was estimated with a deviation of 3% or less using circles or squares as standards. Even when each leaf is estimated as accurately as possible, a deviation in estimating the area obtained can exceed 1%. Results from ratings on arithmetic series are more easily converted to actual areas than those in geometric series.

5.3 Humphries, E. C. & French, S. A. W. (1965) A growth study of sugar beet treated with gibberellic acid and (2 chloroethyl) trimethylammonium chloride (CCC). *Ann. appl. Biol.* **55**, 159–173.

Gibberellic acid sprayed on sugar-beet plants decreased leaf production, but (2-chloroethyl) trimethylammonium chloride (CCC) applied to the soil increased it. These changes were associated with change in shape of the growing point; GA elongated it and CCC flattened it. Leaf area per plant increased to a maximum of about 28 dm^2 at the end of June; CCC consistently decreased it, but GA had no effect, although the plant had fewer leaves than the controls. GA increased petiole length in the first part of the season, but later diminished it. Petiole length increased with amount of GA applied. CCC had the opposite effect, decreasing petiole length at the beginning of the season and afterwards increasing it.

Total dry matter of plants treated with GA was significantly increased at harvests 3 weeks and 8 weeks after initial application. CCC-treated plants had less dry matter throughout. GA increased crown dry weight, and the effect increased with the amount applied. Neither GA nor CCC significantly influenced the weight of storage root. Plants overwintered in an unheated glasshouse continued to increase in dry matter; GA increased the weight of flowering stems, but CCC had no effect.

From observations on individual leaves mean leaf-area growth curves for successive groups of five leaves were constructed. Gibberellic acid increased both areas and longevity of leaves 8–17 and GA-treated plants had the same dry weight as controls in spite of fewer leaves, because leaf area duration was increased. This study shows how different leaves contribute very differently to the total dry matter of the plant. Each of leaves 8–17 had an average duration of 22 dm^2 weeks, and together they produced about two-thirds of the final dry matter in autumn. CCC decreased leaf area duration and dry matter. None of the treatments changed net assimilation rate (E). In previous experiments with mustard plants CCC decreased E, either through a direct inhibitory effect of CCC on photosynthesis or through decrease in photosynthesis because the dwarfed stem in the treated mustard provided only a small sink for photosynthates. In sugar beet CCC does not affect E, possibly because the root provides a large sink.

GA affects sugar beet and potato differently. It hastens leaf senescence in potato, but delays it in sugar beet. GA may prolong the life of sugar-beet leaves

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because it decreases competition between them by decreasing the number of leaves. Gibberellic acid causes a transient increase in leaf growth and dry-matter production both in sugar beet and potato.

5.4 HUMPHRIES, E. C. & THORNE, G. N. (1964) The effect of root formation on photosynthesis of detached leaves. *Ann. Bot.*, N.S. **28**, 393–400.

The CO_2 exchange of fully expanded detached primary leaves of dwarf bean (*Phaseolus vulgaris*) with roots on the petioles was measured. Rates of apparent photosynthesis and respiration increased as roots grew, decreased when roots were removed and increased again as roots regenerated. Rates of photosynthesis of different leaves were highly correlated with the dry weight of root on their petioles. Photosynthesis and respiration were decreased when root growth was restricted by kinetin, and were increased when root growth was stimulated by IAA. Photosynthesis of an attached leaf declined with time, while that of a comparable detached leaf increased. Thus, photosynthesis was correlated with the size of the roots which were the main sink for photosynthates.

5.5 HUMPHRIES, E. C. & WHEELER, A. W. (1964) Cell division and growth substances in leaves. In: *Régulateurs Naturels de la Croissance Végétale, Colloques Internationaux du Centre National de la Recherche Scientifique*, No. 123, Gif-sur-Yvette, 15–20 Juillet 1963. Paris. Editions du Centre National de la Recherche Scientifique, 505–515.

Leaf area is primarily determined by cell number, but what stops cell division is not known. This was investigated by relating the changes in endogenous growth substances (auxins and gibberellins) during the development of the primary leaves and first trifoliate leaf of dwarf French bean (*Phaseolus vulgaris*) to cell division and expansion. Cell number in the primary leaf increased slowly at first, but after the second day increased rapidly and then slowed. In the first and last phases leaf area increased faster than cell number, but in the middle phase area increased directly as cell number. Free IAA was in largest amount in the primary leaves when cells were dividing most rapidly. Gibberellins were detected at all stages of leaf growth, and most was found when leaves expanded fastest; increase in cell size was always associated with decrease in gibberellin content. It is suggested that gibberellin is used up during the process of cell enlargement. Indirect evidence that the nature of the growth substances changes as the leaf develops came from the behaviour of detached primary leaves, with their petioles in culture solution. Leaves in which cell division still continued formed a callus at the base of the petiole, but mature detached leaves formed roots on the petiole.

5.6 THORNE, G. N. & EVANS, A. F. (1964) Influence of tops and roots on net assimilation rate of sugar beet and spinach beet and grafts between them. *Ann. Bot.*, N.S. **28**, 499–508.

Sugar beet has a larger storage root and greater net assimilation rate (E) than spinach beet. To determine whether the greater root was a result or cause of the greater E, grafts were made between tops and roots of sugar beet and spinach beet in all four possible combinations.

Grafted plants with sugar-beet roots had greater E and root dry weight, less leaf area and top dry weight and smaller concentration of sugar in the leaf lamina than those with spinach-beet roots, irrespective of the type of top. Grafted plants with sugar-beet tops had greater E, total and root dry weight, but less leaf area, than those with spinach-beet tops, irrespective of the type of root. The difference in E between grafted plants with sugar-beet tops and spinach-beet tops was similar to that between grafted plants with sugar-beet roots and spinach-beet roots. It increased with time to 60%.

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Increases in E probably represent increases in rate of photosynthesis. Sugar-beet roots probably increased photosynthesis by providing a better sink for assimilates than spinach-beet roots.

5.7 THURSTON, J. M. (1964) Germination of *Alopecurus myosuroides* Huds. (blackgrass). *Proceedings of the 7th British Weed Control Conference* I, 349–351.

Alopecurus in winter wheat germinates mainly in late October and early November. Usually 95% of the seeds germinate within 1 year of shedding, but some become dormant when buried deeply or in waterlogged soil. Seeds remain viable longer when dry than in moist soil. Light and fluctuating temperatures stimulate germination. Increasing soil fertility increases the number of seeds per plant, but decreases the percentage viable seeds.

5.8 THURSTON, J. M. (1964) Weed studies in winter wheat. *Proceedings of the 7th British Weed Control Conference* II, 592–598.

Two weed studies are reported from Broadbalk field, where winter wheat has been grown yearly since 1843 and yields, weather, cultivations and yields recorded. (1) Changing from bare fallow every 5th year to continuous wheat with herbicides increased the total yield over a 5-year cycle by only 10 cwt/acre, decreased weed-seed content of the soil by only 15% and altered the proportion of weed species in favour of those not susceptible to the herbicides used. The responses of 14 species to herbicides and fallowing are compared by twice-yearly surveys of the weed flora on all plots and by the germination of weed seeds in soil samples from selected plots. (2) The distribution of weed seeds between grain fractions and baled straw, and the number left on the ground after combine-harvesting, were investigated by sampling grain and straw, and by catching and sampling the straw and chaff discharged behind the combine before it reached the ground. Only 4% of the total weed seeds were left on the ground after baling, and 4·5% were in the baled straw. The 1st-grade grain contained 28%, the "seconds" 47·5% and the "rubbish" from the third spout 16% of the total weed seeds present at harvest. The distribution between these fractions of 12 species differing in size and texture of seed is discussed.

5.9 WATSON, D. J. & HAYASHI, K.-I. (1965) Photosynthetic and respiratory components of the net assimilation rates of sugar beet and barley. *New Phytol.* **64**, 38–47.

The net assimilation rate (E) of a plant population—the mean rate of increase in total dry weight per unit leaf area, measured over a period of one or two weeks—represents the excess of the rate of photosynthesis of the leaves (P) over the rate of respiration of the whole plant (R), both expressed per unit leaf area ($E = P - R$). To determine P, photosynthesis was prevented on some days during the experimental period by shading plants, and the effect on E was measured. The plants were held in a controlled environment to ensure that external conditions affecting photosynthesis were the same on all days, and effects of change with age in the rate of photosynthesis were avoided by appropriate distribution of the shading days. With these precautions, when n, the number of days when photosynthesis was permitted in an experimental period of 15 days, ranged from 15 to 9, E was linearly related to n. The regression coefficient b of E on n measures the contribution of one day's photosynthesis to E, so the photosynthetic component P of E_N, the net assimilation rate when photosynthesis is permitted every day in an experimental period of N days, is given by Nb. The respiratory component R is estimated by the difference $E_N - P$, or graphically by extrapolating the regression line to $n = 0$.

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This method showed that young sugar-beet plants had a greater E than barley plants solely because they had a greater P; the values of R for the two species were identical.

5.10 WHEELER, A. W. & HUMPHRIES, E. C. (1964) Separation of the effects of gibberellic acid on leaf and stem growth of dwarf French bean. *Nature, Lond.* **202**, 616.

A concentrated ethanolic solution of GA applied to epicotyls of dwarf French bean increased primary leaf growth only transiently, but when applied to the primary leaves it continued to increase their growth and produced larger mature primary leaves than in the controls. GA applied to the epicotyls increased internode extension twice as much as GA applied to the primary leaves.

5.11 (WILLIAMS, G. C.) & THURSTON, J. M. (1964) The effects of temperature in a sack-drier on survival of insects (*Oryzaephilus surinamensis* (L.) (Col., Silvanidae)) and weed seeds (*Avena fatua* L. and *A. ludoviciana* Dur.). *Ann. appl. Biol.* **53**, 29–32.

Three kinds of damp sacks, taking 10 minutes to pass through a drying plant with heating panels at approximately 200° C., were heated to temperatures ranging from 46° to 95° C and remained above 60° C for not more than 5·5 minutes. All insects (*Oryzaephilus surinamensis*) attached to the sacks were killed. Seeds of *A. fatua* and *A. ludoviciana* were more heat-resistant than insects. Even when similar dry sacks with *Avena* seeds attached were passed through the drier at its slowest rate (18 minutes), with the heaters set as hot as possible without damaging the sacks, not more than 40% of the seeds were killed, although temperatures reached 81–135° C, and 105° C was maintained or exceeded for 4–7·5 minutes on the sides and faces of the sacks.

Biochemistry Department

GENERAL PAPERS

6.1 HOLDEN, M. (1965) Chlorophylls. In: *Biochemistry of plant pigments.* ed. T. W. Goodwin. London and New York: Academic Press. Chapter 18, pp. 361–388.

6.2 PIRIE, N. W. (1965) Biogenesis. *Encyclopedic Dictionary.* Freiburg: Verlag Herder. (In the press.)

6.3 PIRIE, N. W. (1964) Food for the needy—facts for the affluent. *New Scient.* **21**, 492.

6.4 PIRIE, N. W. (1964) International biological program. *Lancet* i, 969.

6.5 PIRIE, N. W. (1965) Novel protein sources for use as human food in wet tropical regions. *Proc. Ier Congr. int. des Industr. agric. et aliment. des Zones tropicales et sub-tropicales. Abidjan.* (In the press.)

RESEARCH PAPERS

6.6 BACON, M. F. (1964) Apparatus for quantitative application of samples as streaks in paper and thin-layer chromatography. *J. Chromat.* **16**, 552–553.

The apparatus allows the sample to be applied uniformly along the baseline of the chromatogram, and is suitable for preparative as well as quantitative chromatography.

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6.7 BACON, M. F. (1965) Separation of chlorophylls *a* and *b* and related compounds by thin-layer chromatography on cellulose. *J. Chromat.*, **17**, 322–326.

Chlorophylls *a* and *b*, pheophytins *a* and *b* and pheophorbides *a* and *b* can be separated from each other and from chlorophyllides *a* and *b* on thin layers of cellulose. With precautions, recoveries of chlorophylls and pheophytins exceed 90%, and the method is suitable for quantitative analysis of mixtures of the pigments. Cellulose layers on microscope slides are useful for rapid qualitative work.

6.8 BYERS, M., GREEN, S. H. & PIRIE, N. W. (1965) The presentation of leaf protein on the table. II. *Nutrition.* (In the press.)

Palatable dishes are described containing not less than 20% protein, of which at least half is leaf protein. All the recipes given were analysed for their N contents and the results compared with the theoretical values calculated from food tables. These values ranged from 2·2–5·7% N (14–36% protein); leaf protein contributed between 40 and 75% of the nitrogen present. These figures should be of use to dietitians and others wishing to experiment with, or to demonstrate the use of, leaf protein.

6.9 BYERS, M. & STURROCK, J. W. (1965) The yields of leaf protein extracted by large scale processing of various crops. *J. Sci. Fd Agric.* (In the press.)

The yields of leaf protein that can be expected from the large-scale extraction of several crops grown at Rothamsted were determined by measuring the fresh weight of leaves, the dry matter and nitrogen content of the leaf, and the percentage of protein N extracted.

The yields, expressed as kg of extracted protein per hectare, were greater with cereals than with legumes and other species. The yield depends on species, variety, season, age of the plant and on the ability to regrow after cutting. The response of both wheat and barley to additional fertiliser N varied. More protein is extractable from young leaves, but in general the percentage of N extracted bears little relation to the N content (as % of D.M.) of the leaf.

The results suggest that by using a suitable succession of crops it is possible to get 1,000 kg of protein from a hectare in a year.

6.10 CLARK, A. J. & SHEPHERD, A. M. (1964) Synthetic hatching agents for *Heterodera schachtii* Schm. and their mode of action. *Nematologica* **10**, 431–453.
(For summary see No. 8.5.)

6.11 DAVYS, M. N. G. & PIRIE, N. W. (1965) A belt press for separating juices from fibrous pulps. *J. Agric. Engng Res.* (In the press.)

A tensioned conveyor belt is described on which fibrous pulp is pressed between the belt and a perforated pulley. For an expenditure of 1 h.p. it can handle up to 3 tons an hour and, with the fresh leaf pulp that we use, diminish the moisture content to 70%.

6.12 GREGORY, P. H., FESTENSTEIN, G. N., LACEY, M. E. & SKINNER, F. A. (PEPYS, J. & JENKINS, P. A.) (1964) Farmer's lung disease: the development of antigens in moulding hay. *J. gen. Microbiol.* **36**, 429–439.
(For summary see No. 7.19.)

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6.13 PIRIE, N. W. (1964) The inhibition of infection of *Nicotiana* sp. with the nucleic acid fraction from TMV by a diffusible component of healthy and infected leaves. *Proc. 6th int. Congr. Biochem. New York*, **1**, 154.

Plant Pathology Department

THESIS

7.1 KHALIFA, O. (1964) Some effects of soil and plant treatments on pea rhizosphere in relation to wilt disease. Ph.D. Thesis, University of London.

GENERAL PAPERS

7.2 BAWDEN, F. C. (1964) Viruses in the soil. *Land, Shell Chem. Co.* **17**, 11–13.

7.3 BUXTON, E. W. (1964) Speculations on plant pathogen host relations. In: *Symposia of the Society for General Microbiology* XIV, *Microbial behaviour* "in vivo" *and* "in vitro". Cambridge University Press, pp. 145–164.

7.4 GIBBS, A. J. (1964) Virus diseases of pasture and forage legumes in temperate regions. *Herb. Abstr.* **34**, 141–145.

7.5 GREGORY, P. H. (1964) Microbiology of the air. *Biology hum. Affairs* **29**, 11–18.

7.6 HARRISON, B. D. (1964) The transmission of plant viruses in soil. In: *Plant Virology*. ed. M. K. Corbett & H. D. Sisler. University of Florida Press, pp. 118–147.

7.7 HIRST, J. M. (1964) Fungal epidemics of plants. *Nature, Lond.* **201**, 139–140.

7.8 KASSANIS, B. (1964) Properties of tobacco necrosis virus and its association with satellite virus. [In English and Greek] *Annals Inst. phytopath. Benaki*. (In the press.)

RESEARCH PAPERS

7.9 (ALDRICH, D. T. A.), GIBBS, A. J. & TAYLOR, L. R. (1965) The incidence of bean leaf roll virus in some varieties of field beans (*Vicia faba* L.). *Pl. Path.* **14**, 11–14.

Bean leaf roll virus was consistently more common in field plots of some varieties of spring-sown field beans than others. This difference between varieties was correlated with their susceptibility to infection by the virus, and not to their suitability for colonisation by aphids or to their rate of maturation.

7.10 BAILEY, L. & GIBBS, A. J. (1964) Infection of bees with acute paralysis virus. *J. Insect Path.* **6**, 395–407.
(For summary see No. 11.4.)

7.11 BAILEY, L., GIBBS, A. J. & WOODS, R. D. (1964) Sacbrood virus of the larval honeybee (*Apis mellifera* Linnaeus) *Virology* **23**, 425–429.
(For summary see No. 11.5.)

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7.12 (BRUNT, A. A.) KENTEN, R. H., GIBBS, A. J. & NIXON, H. L. (1964) Further studies on cocoa yellow mosaic virus. *J. gen. Microbiol.* **36.** (In the press.)

Cocoa yellow mosaic virus from Sierra Leone is readily transmitted by sap to many woody and herbaceous dicotyledonous plants. It is serologically related to wild cucumber mosaic virus and to turnip yellow mosaic virus, and has similar chemical and physical properties. It is stable when frozen or lyophilised, inactivated when kept for 10 minutes at 65° C, and is precipitated without loss of infectivity in a half-saturated ammonium sulphate solution. The particles appear to be 25 mμ across when mounted in neutral phosphotungstate, and 29 mμ when shadowed. All preparations contained infective nucleoprotein particles which sedimented at 108 S, and non-infective protein shells which sedimented at 49 S.

7.13 (BRUNT, A. A.), KENTEN, R. H. & NIXON, H. L. (1964) Some properties of cocoa swollen-shoot virus. *J. gen. Microbiol.* **36,** 303–309.

Partially purified preparations of the Kofi Pare isolate of cocoa swollen-shoot virus (CSSV) were usually inactivated after 10 minutes at 50° C, but not after 10 minutes at 45° C. Infectivity of freshly made preparations was greatly lessened by diluting $\frac{1}{10}$, and lost at $\frac{1}{100}$. The infectivity of preparations increased after storage for 24 hours; after 96 hours infectivity was retained at 0–4° C but soon lost at 25° C. The virus survived freezing *in vitro* and, with some loss of infectivity, freezing in leaves and storage in leaves dried over aluminium oxide. Infective material was precipitated from dilute extracts by half saturation with ammonium sulphate at 25° C; it appeared to be equally stable over the range pH 6–8. Preparations of the symptomatologically distinct Kofi Pare, Mampong, Dawa, Nsaba and Bosomuoso isolates all contained similar rod-shaped particles of size about 121 × 28 mμ.

7.14 CLOSE, R. (1964) Some effects of other viruses and of temperature on the multiplication of potato virus X. *Ann. appl. Biol.* **53,** 151–164.

The severity of symptoms shown by tobacco plants infected with potato virus X (PVX) was correlated with virus concentration. The virus multiplied optimally between 20° and 24° C, and increasing temperature above 25° C decreased symptoms and virus concentration. PVX did not multiply detectably in plants at 34° C.

Tobacco leaves systemically infected with both PVX and potato virus Y (PVY) contained more PVX than leaves infected with PVX alone. The greatest relative increase was at 31° C, because at this temperature PVX alone barely multiplied and failed to move out of the inoculated leaf. The concentration of PVY was not altered by the presence of PVX, and the optimum temperature for its multiplication appeared to be 28° C. Three other viruses (namely tobacco mosaic virus, cucumber mosaic virus (yellow strain) and henbane mosaic virus) that multiply at 31° C also assisted the systemic spread of PVX at this temperature, possibly by aiding its movement between mesophyll cells and into the phloem. PVY may also aid PVX at lower temperatures, mainly by increasing the number of cells it infects.

7.15 DEBROT, E. A. (1964) Studies on a strain of raspberry ringspot virus occurring in England. *Ann. appl. Biol.* **54,** 183–191.

A strain of raspberry ringspot virus (RRV-E) infecting blackberry in Essex was transmitted by inoculation of sap to 26 herbaceous species, and caused symptoms in *Nicandra physaloides*, *Datura metel* and *Gomphrena globosa* that differentiated

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it from the Scottish strain of the virus (RRV-S). In sap, with an infection end-point of 10^{-5}, it was inactivated in 10 minutes at 74° C, and in 5 weeks at 23° C. It was precipitated without inactivation by a 30% acetone or 30%-saturated ammonium sulphate solution, but was inactivated when acidified to less than pH 4. Partially purified preparations of RRV-E contained approximately equal amounts of three components with sedimentation rates of 50, 90 and 127S; electron micrographs of preparations mounted in neutral sodium phosphotungstate showed three kinds of particles with diameters about 30 mμ, but with different internal structure. A preparation of RRV-S contained a main component with a sedimentation rate of 129S and a minor one with 50S.

Petunia hybrida, cucumber and French bean seemed equally susceptible to infection with RRV-E when grown in soil containing the nematode vector *Longidorus macrosoma*, but inoculation of sap infected the roots of *P. hybrida* much more readily than roots of the other two species. Cucumber seedlings became infected when exposed for 1 day to infective *L. macrosoma*, and virus-free *L. macrosoma* acquired the virus from plants in 4 days. Infective *L. macrosoma* transmitted readily at 20° C, occasionally at 25° C and not at 30° C; feeding seems inhibited at 30° C. RRV-E was transmitted to seedlings grown in soil containing *L. macrosoma* that had been kept free from plants for 34 days. Of 68 extracts of infective *L. macrosoma* inoculated to *Chenopodium quinoa* plants, only one caused infection.

7.16 GAMEZ, R. & WATSON, M. (1964) Failure of anaesthetised aphids to acquire or transmit henbane mosaic virus when their stylets were artificially inserted into leaves of infected or healthy tobacco plants. *Virology* **22**, 292–295.

When aphids (*Myzus persicae*, Sulz.) were anaesthetised by short exposure to CO_2 and their stylets made to penetrate cells of young tobacco plants infected with henbane mosaic virus (penetration being to a depth commensurate with the insertion of stylets by naturally probing aphids) they did not infect healthy tobacco seedlings; unanaesthetised aphids, allowed to probe on the same plants, did so. When aphids were allowed to probe naturally into infected leaves and then anaesthetised and their stylets made to penetrate leaves attached to healthy seedlings the seedlings did not become infected, although aphids that acquired virus similarly infected plants during natural feeding. A few aphids, anaesthetised after having acquired virus, transmitted it during probes made after recovery from the anaesthetic. These results seem to suggest that some activity of the aphid is needed to transmit henbane mosaic virus, which has previously been thought to be carried passively on the outsides of the stylets.

7.17 GIBBS, A. J. & HARRISON, B. D. (1964) A form of pea early-browning virus found in Britain. *Ann. appl. Biol.* **54**, 1–11.

A form of pea early-browning virus (PEBV), found in many crops of peas and a few of lucerne on sandy soils in Norfolk and Suffolk, was transmitted by inoculation of sap to many herbaceous species. *Chenopodium amaranticolor* and *Phaseolus vulgaris* were useful as indicator plants, and *Nicotiana clevelandii* for propagating the virus. Its thermal inactivation point was 74–78° C, dilution end-point about 10^{-5}, and sap was still infective after 1 year at 20° C. Partially purified preparations contained tubular particles about 20 mμ wide, most of which were about 100 or about 200 mμ long. Isolates from different fields in Britain were closely related serologically, but were only distantly related to a Dutch isolate of PEBV; they seemed serologically unrelated to four other viruses with particles of similar shape and size. Some isolates of PEBV were not readily transmitted using sap as inoculum, but readily with extracts made from leaves

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using water-saturated phenol or bentonite. By contrast with other isolates, they caused recurrent necrotic symptoms in *N. clevelandii*, sap from which did not contain tubular particles.

Pea, lucerne, cucumber, tobacco and sugar-beet seedlings became infected when grown in soil from fields with affected crops. All infested soils contained either *Trichodorus viruliferus* Hooper or *T. primitive* (de Man), sometimes together with other *Trichodorus* spp.; *T. viruliferus* transmitted the virus in experiments. This contrasts with PEBV in the Netherlands, where it is transmitted by *T. teres* and *T. pachydermus*.

7.18 GIBBS, A. J. & HARRISON, B. D. (1964) Nematode-transmitted viruses in sugar beet in East Anglia. *Pl. Path.* **13**, 144–150.

Tobacco rattle virus (TRV) and the English form of tomato black ring virus (TBRV) were obtained from sugar beet showing leaf mottling or blotching at several sites on sandy soils in East Anglia. Infected plants occurred in ill-defined areas of the crops where growth was poor. TBRV-infected plants were commonest in the parts of fields where its vector *Longidorus attenuatus* was most abundant. The nematode *Trichodorus pachydermus* occurred at all outbreaks of TRV and transmitted it in laboratory tests. TBRV was seed- and pollen-borne in sugar beet. The patchy stunting of beet crops on sandy alkaline soils in East Anglia known as Docking disorder probably has several alternative causes or alternative combinations of causes.

7.19 GREGORY, P. H., FESTENSTEIN, G. N., LACEY, M. E. & SKINNER, F. A. (PEPYS, J. & JENKINS, P. A.) (1964) Farmer's lung disease: the development of antigens in moulding hay. *J. gen. Microbiol.* **36**, 429–439.

Antigens important in farmer's lung disease (FLH antigen complex) developed in wet hay ($\geqslant$ 30% water content) 4–6 days after baling; their development was associated with increases in pH value of the hay, in content of soluble and volatile nitrogen, and in numbers of actinomycetes, bacteria and fungi. Most of the antigens were common to the actinomycetes *Thermopolyspora polyspora* and *Micromonospora vulgaris*, but others were unidentified. Brown hay from a self-heated stack contained no FLH antigen except where actinomycetes and fungi had developed and the pH had risen from 4·5 to near 7·0.

7.20 GREGORY, P. H. & LACEY, M. E. (1964) The discovery of *Pithomyces chartarum* in Britain. *Trans. Brit. mycol. Soc.* **47**, 25–30.

Discovery of *Pithomyces chartarum* in Britain followed an unusual sequence of events. After catching air-borne spores in a Hirst trap in 1958, larger concentrations were sought with a Rotorod sampler. Following up the concentration gradient led to where the fungus was flourishing in a favourable environment at Virginia Water, Surrey, on debris of *Holcus lanatus*, from which a toxin-producing strain has been isolated. We suggest that the fungus is indigenous in specialised sites and has hitherto been overlooked.

7.21 HARRISON, B. D. (1964) Specific nematode vectors for serologically distinctive forms of raspberry ringspot and tomato black ring viruses. *Virology* **22**, 544–550.

The forms of raspberry ringspot (RRV) and tomato black ring (TBRV) viruses known from southern England are serologically related to the forms known from Scotland, but only distantly. They also seem to have different vectors. *Longidorus elongatus* (de Man), which transmits the forms of both viruses occurring in Scotland, was not found at outbreaks of the viruses in England. Instead, *L. macrosoma* Hooper occurred where RRV was spreading, and *L. attenuatus*

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Hooper, where TBRV was spreading. Adults and juveniles of *L. macrosoma* readily transmitted the English but not the Scottish form of RRV, or either form of TBRV. Adult females and juveniles of *L. attenuatus* transmitted the English form of TBRV, but in the one test failed to transmit the Scottish form. Ability to be transmitted by a given species of nematode appears to be correlated with the antigenic constitution of the virus.

7.22 HARRISON, B. D. (1964) Infection of gymnosperms with nematode-transmitted viruses of flowering plants. *Virology* **24**, 228–229.

When grown in soil containing virus-carrying *Xiphinema diversicaudatum*, the roots of *Chamaecyparis lawsoniana*, but not those of *C. pisifera*, became infected with arabis mosaic virus. Similarly, roots of *Picea sitchensis* became infected when exposed to *Longidorus attenuatus* carrying the English form of tomato black ring virus, but not when exposed to *Trichodorus* spp. carrying either pea early browning or tobacco rattle viruses.

7.23 KASSANIS, B. & KLECZKOWSKI, A. (1965) Inactivation of a strain of tobacco necrosis virus and of the RNA isolated from it, by ultraviolet radiation of different wavelengths. *Photochem. Photobiol.* **4**, 209–214.

A strain of tobacco necrosis virus (TNV) and infective nucleic acid isolated from it (TNV-RNA) are equally susceptible to inactivation by ultraviolet radiation (UV) at all wavelengths tested (230–290 mμ) and can be photoreactivated to the same extent by exposing inoculated host plants to daylight. The shape of the action spectrum for inactivation by UV of TNV and of TNV-RNA follows that of the absorption spectrum of TNV-RNA. Thus, unlike the RNA of tobacco mosaic virus, the RNA of TNV behaves in all these respects in the same way irrespective of whether it is inside or outside the virus particle. To inactivate TNV or TNV-RNA to 50% of their original infectivities, each mg of RNA must absorb about 0·27 joules of radiation energy of any wavelength between 230 and 290 mμ, which corresponds to a quantum yield of about $0{\cdot}65 \times 10^{-3}$ at 260 mμ.

7.24 KASSANIS, B. & MACFARLANE, I. (1964) Transmission of tobacco necrosis virus by zoospores of *Olpidium brassicae*. *J. gen. Microbiol.* **36**, 79–93.

Strain D of tobacco necrosis virus (TNV) was transmitted by zoospores of three different isolates of *Olpidium brassicae* (Wor.) Dang. to roots of Mung bean and lettuce grown in modified Hoagland's solution diluted $\frac{1}{20}$. On Mung bean roots necrotic local lesions formed 1 day after exposure to virus and zoospores. Virus in lettuce was assayed by inoculation to leaves of French bean. Virus transmission was favoured by decreasing salt concentration and increasing the pH value of the nutrient solution, and depended also on the concentrations of virus and zoospores. With 10^5 zoospores/ml transmission to lettuce was obtained with as little virus as 0·05 μg/l. When the virus concentration was 5 μg/l, 50–100 zoospores/ml were effective. Fungus infection as measured by the number of zoosporangia in the root was not strictly correlated with virus infection.

Exposure of roots to virus + zoospore mixture for 1 minute sufficed to infect them with virus. More transmission occurred when virus was added before or together with zoospores than after. Roots, exposed to zoospores for 10 minutes, then washed, were more readily infected by TNV when virus was introduced during the first hour or two after zoospore attachment to the root cells than later; there was some transmission even when virus was withheld till 4 hours after washing. Immersing roots, inoculated with fungus and virus, in hot water

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(60°) killed the fungus but not the virus, and varying the interval between inoculation and heating showed that virus became established after 2–3 hours.

Isolates of *Olpidium brassicae* naturally contaminated by strain D or A of TNV were freed from contamination by inoculating lettuce roots with dilute zoospore suspensions. Zoospores mixed or naturally contaminated with TNV were partially separated from it by centrifugation. Virus transmission was prevented by adding concentrated homologous antiserum to zoospores that had already been exposed to virus, or by adding very dilute antiserum to virus before mixing it with zoospores. The extent to which transmission was prevented by antisera to other strains of TNV depended on the degree of their serological relationship to strain D. The present evidence does not support the suggestion that TNV is carried inside the fungus.

7.25 KASSANIS, B. & MACFARLANE, I. (1964) Transmission of tobacco necrosis virus to tobacco callus tissue by zoospores of *Olpidium brassicae*. *Nature, Lond.* **201**, 218–219.

Tobacco callus tissues grown in agar medium were infected with *Olpidium brassicae* and formed mature sporangia, whereas previously only roots were known to be susceptible to this fungus. Using three different isolates of *Olpidium*, serotypes A and D of tobacco necrosis virus were transmitted to tobacco callus tissues. Callus tissues are difficult to infect by virus, and transmission by *Olpidium* is an improvement on previous methods.

7.26 KLECZKOWSKI, A. (1965) Effect of U.V. irradiation on susceptibility of serum albumins to trypsin. *Photochem. Photobiol.* **3**, 115–120.

Ultraviolet irradation converts bovine serum albumin (BSA) and rabbit serum albumin (RSA) into forms much more rapidly hydrolysed by trypsin than the original proteins. The radiation energy (at 2,537 Å) required to be absorbed by each mg of a protein to convert half of it into a form susceptible to trypsin ($E50\%$) is about 0·32 J for BSA and 0·62 J for RSA. The average $E50\%$ for inactivation of enzymes and antibodies is 0·7 J, so the two processes may depend on similar alterations in irradiated protein molecules. The alteration can be considered as denaturation, with protein molecules becoming at least partially unfolded and making the sites susceptible to the attack by trypsin more easily accessible to the enzyme.

7.27 KLECZKOWSKI, J. & KLECZKOWSKI, A. (1965) Inactivation of a Rhizobium bacteriophage by ultraviolet radiation of different wavelengths. *Photochem. Photobiol.* **4**, 201–207.
(For summary see No. 4.4.)

7.28 LACEY, J. & LACEY, M. E. (1964) Spore concentrations in the air of farm buildings. *Trans. Brit. mycol. Soc.* **47**, 547–552.

Concentrations up to 1,600 million spores/m³ air were recorded in farm buildings while hay was being shaken. The concentration decreased by 90% in 20 minutes. Actinomycetes spores formed up to 98% of the total. *Micromonospora vulgaris* was the most abundant species isolated. *Mucor pusillus*, *Absidia ramosa*, *Aspergillus fumigatus*, *A. terreus* and *A. nidulans*, all potentially pathogenic to man and animals, were the most frequently isolated fungi.

7.29 (RAM REDDY, M. A.), SALT, G. A. & (LAST, F. T.) (1964) Growth of *Picea sitchensis* in old forest nurseries. *Ann. appl. Biol.* **54**, 397–414.

The poor yield of Sitka spruce (*Picea sitchensis*, Carr.) seedlings in old forest nurseries at Kennington and Ringwood results from losses of seedlings during germination and stunted growth of those that survive.

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Losses, which are attributed mainly to invasion by *Pythium* spp. and secondarily by *Cylindrocarpon radicicola* Wr. and *Fusarium* spp., were decreased by: (*a*) partially sterilising soil with formalin, dazomet or metham-sodium; (*b*) applying the fungicides maneb and quintozene to soil; and (*c*) dressing the seed with fungicides. In contrast, only partial sterilisation increased growth of the survivors.

Fungicidal seed-dressings, which did not affect growth, increased numbers of survivors most in partially sterilised soils, suggesting that soil microfloras developing after partial sterilisation controlled seed-borne pathogens no more effectively than do the microfloras of unsterilised soils.

Experiments with transplants indicated that the growth stimulus from partial sterilisation operated equally at all stages of seedling development, and was independent of root damage done by parasites.

7.30 SALT, G. A. (1964) The incidence of *Oospora pustulans* on potato plants in different soils. *Pl. Path.* **13**, 155–158.

The incidence of the brown cortical rot of underground parts of potato plants caused by *Oospora pustulans* Owen and Wakefield was estimated on plants lifted from maincrop potato variety trials in several districts of England and Wales during August in 1955, 1956 and 1957. Infection was considerable in the varieties Majestic, King Edward, Dr. McIntosh, Orion, Ulster Torch and Redskin, slight in Ulster Supreme and Arran Viking, and intermediate in Ulster Beacon and Ulster Tarn. Stem bases were least infected on neutral peat (Black fen) and alluvial soils, rather more on light loams and most on clay soils. Microscopic lesions in the eyes of seed tubers were at least as important as visible skin spots as sources of infection for the new crop.

7.31 SERJEANT, E. P. (1964) Cocksfoot mottle virus. *Pl. Path.* **13**, 23–24.

Cocksfoot mottle virus, previously undescribed, occurs extensively in seed crops and leys in S.E. England. Its field transmission is obscure, but manual transmissions in the glasshouse infected wheat (Cappelle Desprez) and oats (Blenda). The virus particle is "spherical", about 30 mμ in diameter and apparently is not serologically related to Weidelgrassmosaikvirus.

7.32 WATSON, M., SERJEANT, E. P. & LENNON, E. A. (1964) Carrot motley dwarf and parsnip mottle viruses. *Ann. appl. Biol.* **54**, 153–166.

Carrots that show symptoms of carrot motley dwarf contain two viruses, carrot mottle virus (CMV) and red-leaf virus (RLV). CMV cannot be manually inoculated to carrot, but can be to some other members of the Umbelliferae, as well as to some species of the Solanaceae, Leguminoseae and Chenopodiaceae. The host range of RLV is limited to the Umbelliferae, and it is not manually transmissible, but was transmitted by grafting. *Cavariella aegopodiae* Scop. transmits RLV alone, but will transmit CMV only from plants infected with both viruses. Thus aphids were unable to transmit from coriander plants manually inoculated with CMV, but after these plants were infected with RLV by aphids virus-free aphids acquired and transmitted both viruses from them.

Aphids remain infective with both viruses for 1–2 weeks, and retain infectivity through the moult. A minimum total of about 9 hours is needed for acquisition and transmission; vector-efficiency increases with increasing feeding times up to several days.

The viruses causing motley dwarf become attenuated in the glasshouse after continued aphid-transmission; avirulent isolates protect their hosts against infection by virulent ones.

Infectivity of saps from CMV infected plants was increased by extraction at high pH in the presence of a trace of Zn, and was associated in carrot with

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particles 30 mμ in diameter. Water–phenol extracts are almost as infective as extracts in buffer, but are inactivated by 0·02 μg/1 pancreatic ribonuclease.

Parsnip mottle virus (PMV) resembles CMV in many ways, but also differs in some important respects. Unlike CMV, it infects celery and parsnip, and it is transmitted by *C. pastinacae*, as well as *C. aegopodiae*, which is the only vector of carrot motley dwarf (CMV in combination with RLV). PMV is transmitted by aphids from plants infected with it alone, whether these plants were infected by aphids or by manual inoculation.

Carrot plants infected first with PMV and then with the motley dwarf virus complex developed symptoms of motley dwarf, but in coriander the reverse happened. CMV and PMV appear to interfere with each other's multiplication in the hosts, but CMV is dominant in carrot and PMV in coriander. They have some properties of distantly related strains.

Nematology Department

Book

8.1 Jones, F. G. W. & Jones, M. G. (1964) *Pests of field crops*. London: Edward Arnold, viii, 406 pp., 32 half-tone plates, 133 line diagrams.

General Papers

8.2 Peachey, J. E. (1964) Chemical soil sterilisation. *Agric. vet. Chem.* **5**, 53–55.

8.3 (Peacock, F. C.) & Peachey, J. E. (1965) Systemic control of plant nematodes. *Adv. Chemotherapy* **2**. (In the press.)

8.4 Webster, J. M. (1964) Biological races in species of plant parasitic nematodes. *Parasitology* **54**, 8P.

Research Papers

8.5 Clarke, A. J. & Shepherd, A. M. (1964) Synthetic hatching agents for *Heterodera schachtii* Schm. and their mode of action. *Nematologica* **10**, 431–453.

Two hundred and eighty-three compounds were tested for hatching activity. Thirty one gave hatches equal to or greater than beet root diffusate. No correlation was found between hatching activity and redox potential for the 25 redox compounds examined. The structure of the artificial hatching agents and the mechanism of hatching are discussed.

8.6 (Coomans, A.) & Goodey, J. B. (1965) *Dricephalobus congoensis* n.g., n.sp. *Nematologica* **11**. (In the press.)

D. congoensis has an offset head, large cup-shaped amphids, a large excretory gland cell, reflexed prodelphic female gonad and pointed tail. The male has spicules and gubernaculum. The new genus is intermediate between the Cephalobidae and Drilonematidae.

8.7 Doncaster, C. C. (1964) The effects of "D-D" treatments applied during a five-course rotation on the soil population of *Heterodera rostochiensis* Woll. *Ann. appl. Biol.* **54**, 391–396.

In an infested field, which was planted with potatoes in the 1st and 6th years and with other crops in the 2nd to the 5th years, plots were injected with "D-D"

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at 400 lb/acre. In untreated plots the eelworm population approximately halved each year potatoes were not grown. After 4 years under other crops the population was the same regardless of the year in which "D-D" was injected. Only injections repeated in 4 or 5 successive years decreased the population so much that it remained small after potatoes were grown in the 6th year.

8.8 DONCASTER, C. C. (1964) Four patterns of observation chamber for studying nematode behaviour. *Nematologica* **10**, 306–312.

Nematode behaviour was studied in agar culture dishes fitted with large coverglass bases and close-fitting lids. Dishes were inverted for microscopic examination. Sealed observation chambers made from two large coverslips separated by a variable number of gaskets were used for nematodes in agar or water, and perfusion chambers were used for specimens that needed their culture medium replenishing frequently. A chamber for observing at great magnification the nematodes in roots contained sand whose moisture content could be controlled. This chamber can be perfused and can hold whole seedlings.

8.9 DONCASTER, C. C. & CLARK, S. A. (1964) Observations on gut pH and absorption of methyl red and neutral red in the intestinal walls of *Pelodera* and *Mesodiplogaster*. *Nematologica* **10**, 136–140.

The intestinal contents of some nematodes are acid, but of others are probably alkaline. Methyl red and neutral red ingested by *Pelodera* (*Cruznema*) *lambdiensis* and by a *Mesodiplogaster* sp. showed the oesophageal and intestinal contents were just acid and the granular contents of cells of the intestinal wall were acid to different degrees. In *Pelodera*, cells just behind the anterior tip of the intestine were usually most acid. The intestinal wall of *Pelodera* and *Mesodiplogaster* absorbed neutral red and methyl red in variable amounts, and there was selective absorption in different regions of the intestine by *Pelodera*.

8.10 FRANKLIN, M. T. (1965) A root-knot nematode, *Meloidogyne naasi* n.sp., on field crops in England and Wales. *Nematologica* **11**, 79–86.

Meloidogyne naasi n.sp. is described from cereals, grasses and sugar beet in west and south-west England and Wales. It is distinguished by the perineal pattern and the forward position of the excretory pore in the female, by the long slender tail of the larva and by the protruding first head annule in the male. Both larva and male have a curious structure resembling a group of small vesicles in the anterior part of the median oesophageal bulb.

8.11 GOODEY, J. B. & HOOPER, D. J. (1965) A neotype of *Aphelenchus avenae* Bastian, 1865 and the rejection of *Metaphelenchus* Steiner, 1943. *Nematologica* **11**, 55–65.

A neotype of *Aphelenchus avenae* is described and figured; observations are made on the development and variation shown by the progeny of topotypes cultured on fungal plates. The oesophagus may or may not overlap the intestine. *Metaphelenchus rhopalocercus* and *M. micoletzkyi* show similar variation. These two species are made synonyms of *A. avenae*, and *M. sacchari* is declared *species inquirenda*.

8.12 GREEN, C. D. (1964) The effect of high temperatures on aqueous suspensions of stem eelworm *Ditylenchus dipsaci* (Kühn). *Ann.appl. Biol.* **54**, 381–390.

The relationship between the time and temperature necessary to kill *Ditylenchus dipsaci* in hot water suggests that the cause of death at 48° differs from that below

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46° C, for survivors from one hot-water treatment can survive a second, but can be susceptible to storage temperatures not lethal to untreated nematodes.

Acclimatisation increases the resistance of the nematodes to heat and can make hot-water treatment ineffective. Storage at 25–30° C after hot-water treatment increases the proportion of dead nematodes and, if hot-water treated, infested bulbs were so stored, might improve control.

8.13 GREET, D. N. (1964) Observations on sexual attraction and copulation in the nematode *Panagrolaimus rigidus* (Schneider). *Nature, Lond.* **204**, 96–97.

Observation of cultures of *P. rigidus* suggested that the apparently reflex responses in the male which led to copulation were initiated by both chemical and tactile stimuli. Each sex apparently produces specific, water-soluble attractants of molecular weight small enough to diffuse through "Cellophane". Copulation occurred only after the posterior third of the male touched any part of the female, suggesting that other areas of the male are not responsive.

8.14 HOOPER, D. J., (KUIPER, K. & LOOF, P. A. A.) (1964) Observations on the identity of *Trichodorus teres* Hooper, 1962 and *T. flevensis* Kuiper & Loof, 1962. *Nematologica* **9**, 646.

The presence of lateral body pores on females of *Trichodorus flevensis* was the only character separating them from the females of *T. teres* Hooper, 1962, but both have now been found to have a variable number of lateral body pores, mainly posterior but sometimes anterior, to the vulva. Males were not found in English populations of *T. teres*; they were found in some but not all populations of *T. flevensis*. With no other distinguishing character between the females, the authors agree that *T. flevensis* is a synonym of *T. teres*, the first published name.

8.15 JONES, F. G. W., MEATON, V. H., PARROTT, D. M., SHEPHERD, A. M. & (KING, J. M.) (1965) Population studies on pea cyst-nematode. *Ann. appl. Biol.* **55**, 13–23.

Changes in populations of *Heterodera goettingiana* Liebs. were studied in microplots containing three kinds of soil. When planted in soil containing a population of eelworms made uniform by mixing, varieties of pea that matured quickly bore fewer cysts and eggs than later-maturing varieties, although all varieties grew long enough for the eelworms to complete their life cycle. Field bean behaved like the late, and broad bean like the early pea varieties.

When one variety of pea was grown on plots with different population densities yield decreased in proportion to the density of the eelworm population before planting. The relationship between yield and initial population over a narrow population range was expressed equally well by the simple equations $Y = a + bx$ or $Y = a + b \log x$, where Y = yield, x = the number of eggs, a = the Y intercept and b = the regression coefficient. For plots with a wide range of initial populations (4–359 eggs/g soil) neither equation was adequate and the relationship was best fitted by a sigmoid curve.

Two sets of plots tested the influence of two population levels, nitrogen versus no nitrogen, and light versus heavy soil. Soils and population levels affected yield significantly; nitrogen increased yield on the heavy but not on the light soil. Only soil type affected the final population density, that in the heavy soil which gave the greater yield being twice as great.

When peas were grown, the final population rose to a maximum that was independent of the initial population density, and was determined by the number of females (new cysts) formed. Their number was almost constant over the whole initial population range, and they produced on average 129 eggs/cyst, which was

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the maximum theoretically possible rate of increase under the conditions of the experiment. At small initial egg densities (4 eggs/g) about 50% of the eggs became female and at great densities (359 eggs/g), not more than 1%.

Final populations in the microplots bore no relationship to yield of peas. The size and form of the central part of the root system apparently determines how many females the roots can support, and root size seems one of the factors that determine the final population.

8.16 (Luc, M.), Lima, M. B., (Weischer, B. & Flegg, J. J. M.) (1964) *Xiphinema vuittenezi* n.sp. (Nematoda: Dorylaimidae). *Nematologica* **10**, 151–163.

Xiphinema vuittenezi n.sp., found in France, Portugal, Germany, England and the U.S.A., is characterised by the rounded tail with short peg, the vulva in the middle of the body, two ovaries, the offset lip region and the appearance of the anterior end of the body. Males are rare.

X. vuittenezi differs from *X. diversicaudatum* mainly by being smaller, having a more posteriorly placed vulva, a shorter tail, narrower anal-body-width, a shorter and more ventrally placed tail peg, in addition to the rarity of males. From *X. index* the new species differs primarily in the position of the vulva, the considerably shorter tail peg and the shape of the anterior end and lip region. *X. mammillatum* is shorter and fatter than *X. vuittenezi*, has a more anterior vulva and only slightly offset lip region. *X. vuittenezi* has been found on grape vines, sugar cane, quince, apricot, black currant, scots pine and apple.

8.17 Peachey, J. E. & (Brown, E. B.) (1965) Ridding a glasshouse soil of dagger nematode before planting with roses. *Expl. Hort.* No. 13 (In the press.)

"D-D" at 800 lb/acre killed *Xiphinema diversicaudatum* in a Lea Valley glasshouse soil. Freshly grafted rose bushes planted in the fumigated soil grew well and produced an above-average crop of blooms. Rose trees grown on soil steamed after fumigation produced taller bloom of slightly better quality than those grown in soil fumigated but not steamed.

8.18 Peachey, J. E., Green, C. D. & Greet, D. N. (1965) The effects of "D-D" and "Nemagon" on eight-year-old rose bushes infested with dagger nematode. *Expl. Hort.* No. 13 (In the press.)

"Nemagon" (dibromochloropropane) at 5·8 gal/acre, emulsified and drenched into the soil, improved the colour of leaves of established rose bushes, diminished galling of roots by *Xiphinema diversicaudatum* and decreased the numbers of surviving dagger nematodes by 60% after 3 weeks and 90% after 14 weeks; "D-D" was less effective.

8.19 Peachey, J. E. & Greet, D. N. (1965) Control of potato cyst nematode with dazomet. *Pl. Path.* **14**, 18.

Dazomet (85% dust formation of tetrahydromethylthiadiazine thione) at 350 lb/acre, even when applied in unfavourable conditions that did not allow for the recommended degree of mixing, controlled potato cyst-nematodes well enough in the ridges to obtain yields comparable to those where dazomet was adequately mixed into the soil.

8.20 Peachey, J. E., Greet, D. N., Hooper, D. J. & Chapman, M. R. (1965) The effects of two soil types on diffusion of soil sterilants. *Pl. Path.* **14**, 36–38.

Small plots of sandy clay loam and loam in the same glasshouse were injected with 110 gal/acre of "D-D" (dichloropropane—dichloropropene), "Vorlex"

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(20% methyl isothiocyanate + 80% dichloropropane–dichloropropene) or "Trapex" (40% methyl isothiocyanate). In the sandy clay loam all the nematodes were killed by all the treatments, but in the loam soil methyl isothiocyanate was ineffective because of its physical properties and the smaller porosity of this soil.

8.21 POINAR, G. O., Jr. (1965) An association between *Pelodera* (*Coarctadera*) *acarambates* n.sp. (Rhabditina: Nematoda) and macrochelid mites (Mesostigmata: Acari). *Nematologica* **10**, 507–511.

Pelodera (*Coarctodera*) *acarambates* n.sp. is described. Its diagnostic characters are: distinct lips, collar enclosing 40–57% of the stoma, ovaries reflexed past the vulva, female tail long and male with forked gubernaculum with a reflexed tip. *P. acarambates* forms ensheathed dauer larvae on the backs of the mites, *Macrocheles glaber* (Müller) and *M. submotus* Falconer. Although this is a phoretic relationship for the nematode, the mites are predacious and probably feed on nematodes. The habits of *P. acarambates* are compared with those of the five other species in this subgenus.

8.22 POINAR, G. O., Jr. (1965) A new nematode, *Orthomermis oedobranchus* gen.n., sp.n. (Mermithidae) parasitising *Smittia* larvae (Chironomidae) in England. *Nematologica* **10**, 501–506.

Orthomermis oedobranchus gen.n., sp.n., a primitive member of the family with a swollen vulvar fin, is described and its relationship in the Mermithidae discussed. Most individuals complete their final moult (which is double) in 4 days, but do not develop adult head characters until 1–2 weeks later, an unusual feature in this group. Egg laying begins during moulting or immediately afterwards. This nematode parasitises the larval stage of the three insect species, *Smittia* sp. (Chironomidae), *Omalium caesum* (Staphilinidae) and *Lycoriella solani* (Sciaridae). All hosts died after the nematodes emerged.

8.23 POINAR, G. O., Jr. & DONCASTER, C. C. (1965) The penetration of *Tripius sciarae* (Bovien) (Sphaerulariidae: Aphelenchoidea) into its insect host, *Bradysia paupera* Tuom. (Mycetophilidae: Diptera). *Nematologica* **11**, 73–78.

Mated, adult females of *Tripius sciarae*, enclosed in the last larval cuticle, penetrate larvae or pupae of the fly, *Bradysia paupera*, first, by adhering to the host's cuticle; then, with their spears and possibly also by enzyme action, they make a perforation through which the lip region is forced. By twisting the head, the hole is enlarged. The nematode adheres by a sticky mass formed from the front part of its last larval cuticle, which is dissolved by salivary secretions. As the nematode penetrates, its ensheathing cuticle is left attached to the host by the adhesive mass, and this seals the penetration hole.

Spear thrusting within the host lasts for a while, but is not associated with feeding, because the stylet and intestine are not connected.

8.24 RAO, G. N. & PEACHEY, J. E. (1965) The effects of adding larvae of potato cyst-nematode to potatoes grown in pots. *Pl. Path.* **14**, 15–18.

The number of larvae that invaded the root systems of potted potato plants and the number of cysts formed on the roots increased with increasing numbers of larvae in the initial inoculum, but not in direct proportion, for as the number in the inoculum increased the proportion that invaded and became cysts decreased; more became cysts when inoculation was at planting or 2 weeks afterwards than when earlier or later. Late inoculation decreased the adverse effect of larvae

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on yield of tops and tubers, but root weights were greatest when pots were inoculated before planting.

8.25 SHEPHERD, A. M. (1963) A water sprinkler to separate *Heterodera* cysts from debris in hatching tests. *Nematologica* **9**, 647.

8.26 WEBSTER, J. M. (1964) Interaction of temperature and suction in relation to movement of eelworms. *Nature, Lond.* **202**, 574–575.

The average distance moved by *Ditylenchus dipsaci* through a column of sand was measured at different temperatures and suctions. The relationship between temperature and nematode movement was curvilinear, with most movement at 20° C. Maximum movement coincided with the point of inflexion of the moisture characteristic, but temperature influenced the suction at which mobility was greatest. Between 10° and 20° C mobility was great over a wide range of suctions, whereas at both extremes (5–10° C and 25–30° C) it decreased greatly when suction rose above the point of inflexion of the moisture characteristic. There was an optimum number of body undulations in unit time to progress through pore spaces. When nematode suspensions were kept at different temperatures for 4 hours their activity increased linearly with increase in temperature. Thus, when cold the nematodes are inactive and less able to overcome the resistance of water films at strong suctions. At high temperatures and weak suctions activity and mobility are great and the eelworms can then swim in the pore spaces.

8.27 WEBSTER, J. M. (1964) Population increase of *Ditylenchus dipsaci* (Kühn) in the narcissus and the spread of the nematode through the soil. *Ann. appl. Biol.* **53**, 485–492.

The population density of the narcissus race of *Ditylenchus dipsaci* in soil was estimated by counting how many invaded batches of 40 onion seedlings grown in pots. In narcissus bulbs *D. dipsaci* increased progressively, reaching a peak at the end of the growing season. The increase in May/June was associated with increasing temperature. Larger inocula added to potted bulbs significantly increased the number in the foliage but not in the bulbs. Nematodes moved actively and were transported passively both up and down within the host plant. The presence of spikkels was associated with nematodes in the active intercalary meristem.

Movement between the plant and the soil, mostly via the base of the bulb, continued throughout the growing season. After dried leaf tissue was wetted nematodes continued to move from it for more than 60 days. The nematode moved through soil slowly unless carried by water or cultivations.

8.28 WEBSTER, J. M. (1964) The effect of storage conditions on the infectivity of narcissus stem eelworm. *Pl. Path.* **13**, 151–154.

The temperature at which narcissus bulbs, infected with *Ditylenchus dipsaci*, were stored affected the rate the nematodes multiplied, which, in turn, governed the length of life of the infested bulbs; but the greatest number of nematodes were extracted from bulbs which survived longest. When *D. dipsaci* was stored as "eelworm wool" in dried foliage its viability and ability to infect diminished with increasing duration of storage. The hotter the bulbs were stored, the more high humidity diminished the infectivity of the nematodes. Infectivity was greater during winter and early spring than during summer.

8.29 WHITEHEAD, A. G. & HEMMING, J. R. (1965) A comparison of some quantitative methods of extracting small vermiform nematodes from soil. *Ann. appl. Biol.* **55**, 25–38.

When 200 ml dispersed soil is sedimented from an obliquely rising water current in a simple compartmented tank about three-quarters of the nematodes are

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extracted. About 95% of the nematodes in the concentrated suspension can be separated finally from mineral and heavy organic particles by centrifugal flotation. When mobile nematodes were finally separated from soil particles by paper tissue this sedimentation method extracted as many nematodes as the standard two-flask and elutriation methods from sand and loam, but in one test extracted fewer *Tylenchorynchus* from clay, and in another fewer *Paratylenchus* from clay than the elutriation method. The method is quicker (4 or 6 instead of 30–45 minutes) and easier.

Mobile nematodes can be extracted from 300 ml soil spread out on paper tissue in 23 × 33-cm trays of 8 mesh/cm phosphor-bronze gauze, just resting on shallow water. The suspension obtained after 24 hours at 16–18° C was concentrated to 10–15 ml without loss by sedimentation in two tapered cylinders, one of 8 cm bore, the other of 2·6 cm bore. This method usually extracted significantly more nematodes than the sedimentation, two-flask or elutriation method.

8.30 YUEN, P. H. (1965) Four new species of *Helicotylenchus* Steiner (Hoplolaiminae: Tylenchida) and a redescription of *H. canadensis* Waseem, 1961. *Nematologica* **10**, 373–387.

Five digonic species of the genus *Helicotylenchus* Steiner are described from Broadbalk Wilderness, with a brief note on their distribution and specific status: *H. broadbalkiensis* n.sp.; *H. vulgaris* n.sp.; *H. paxilli* n.sp.; *H. varicaudatus* n.sp.; and *H. canadensis* Waseem, 1961.

H. broadbalkiensis n.sp. is characterised by a small almost square-shaped head, which is offset and marked by four or five narrow annules. Typically the tail is conoid, with curvature mainly on dorsal side, tapering to a point ventrally but flattening somewhat distally. *H. vulgaris* n.sp. can be distinguished from all described species of the genus by the short tail, with doubling of the distal tail annules, and short isthmus. *H. paxilli* n.sp. is very similar to *H. microlobus* Perry, in Perry, Darling and Thorne, 1959, but differs from it in the greater number of head annules, the shape of the head and spear knobs, and the value of C. *H. varicaudatus* n.sp. shows great variation in tail shape. The annules at the top of the tail are usually irregular.

8.31 YUEN, P. H. (1965) The female gonad in the subfamily Hoplolaiminae with a note on the spermatheca of *Tylenchorhynchus*. *Nematologica* **10**, 570–580.

A morphologically similar spermatheca was found in the gonads of monosexual and bisexual species of all six genera of the subfamily Hoplolaiminae Filipjev: *Hoplolaimus* Daday, *Scutellonema* Andrássy, *Aorolaimus* Sher, *Peltamigratus* Sher, *Rotylenchus* Filipjev and *Helicotylenchus* Steiner, and of *Tylenchorhynchus* Cobb. The offset "spermagonium" reported in some monosexual *Helicotylenchus* species is thought to be an offset spermatheca. Reproduction in monosexual species in all genera studied is probably parthenogenetic. Some apparently monosexual *Helicotylenchus* species may occasionally be impregnated by males.

Insecticides and Fungicides Department

GENERAL PAPERS

9.1 LORD, K. A. & SOLLY, S. R. B. (1963) Control of pests—Insecticides. *Rep. Progr. appl. Chem.* **48**, 462–471.

9.2 POTTER, C. (1964) Selective control of insect pests. *Food Supply and Nature Conservation Symposium*. Cambridge College of Arts and Technology, April.

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9.3 SAWICKI, R. M. (1964) Some general considerations on house-fly rearing techniques. *Bull. Wld Hlth Org.* (In the press.)

RESEARCH PAPERS

9.4 ARNOLD, A. J. & LORD, K. A. (1965) A simple injection port and column holder for use in Gas Chromatography. *J. scient. Instrum.* **42**, 47.

The injection port and column holder fits directly into a commercial oven and supports both column and detector. A sliding "O" ring connection between the column and injection port makes it easy to change hot columns rapidly.

The equipment is used for routine measurements of chlorinated and organophosphorus insecticide residues using an electron capture detector.

9.5 BARDNER, R. (1964) The uptake of phorate, a systemic insecticide, applied as a slurry to wheat and mustard seeds. *Ann. appl. Biol.* **53**, 445–458.

The absorption by plants of wheat and mustard of a systemic organophosphorus insecticide (phorate), applied as a slurry seed dressing, was studied by caging the aphid *Rhopalosiphum padi* (L.) on the foliage of wheat, and the aphid *Brevicoryne brassicae* (L.) and the Chrysomelid beetle *Phaedon cochleariae* (F.) on white mustard, grown from phorate-treated seed.

Wheat and mustard plants quickly lost their toxicity to insects when they were transplanted, suggesting that most of the insecticide from a slurry applied to seed passes into the soil and is picked up by the roots. That phorate or its derivatives occur in the soil was shown by tests of anticholinesterase activity. Insecticide can also pass into the seed of wheat and move to the growing embryo. Phorate becomes closely bound to the testa of mustard, but does not penetrate it to reach the cotyledons or other parts of the embryo. Mustard cotyledons can become contaminated by insecticide as they emerge through the soil.

Young and old leaves of both wheat and mustard depend on continued absorption of insecticide from the soil to maintain their toxicity. Insecticide does not move from old to young leaves. Old leaves lose their toxicity to insects more slowly than young ones. When treated seeds are sown close together the overlapping zones of insecticide round each seed can increase strength and persistence of insecticidal effect. This happens more with dimethoate, which readily dissolves in water, than with phorate, which is almost insoluble. At usual sowing rates the zones of insecticide round each seed would rarely overlap.

Roots of wheat and mustard from treated seed did not excrete insecticide, and the roots did not carry insecticide through the soil.

9.6 BROADBENT, L., BURT, P. E. & HEATHCOTE, G. D. (1964) Home production of seed for early potatoes. 6. Insecticides applied to the soil or tubers. *Expl Hort.* **11**, 40–50.

The systemic insecticides dimethoate, disulfoton, menazon and phorate applied in the soil as granular formulations before potato tubers were planted, and menazon applied directly to the tubers, kept the plants almost free from aphids for several weeks after the foliage emerged, and prevented or greatly limited the spread of leaf-roll virus. In a year when leaf roll spread more than usual, disulfoton and phorate were most effective in checking spread. The spread of virus Y was occasionally checked, but incidence was seldom less than half that in untreated plots.

Such undesirable side effects as crop damage, loss of yield and the presence of

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residues in the tubers were negligible at the rates at which the insecticides were applied.

This method of controlling aphids and virus diseases is better than the frequent spraying of the foliage with insecticides, because it costs no more and damages the crop less.

9.7 BURT, P. E., HEATHCOTE, G. D. & BROADBENT, L. (1964) The use of insecticides to find when leaf roll and Y viruses spread within potato crops. *Ann. appl. Biol.* **54**, 13–22.

Attempts to find when leaf roll and Y viruses spread within Majestic potato crops, made during 4 years at Harpenden by spraying with aphicides to restrict virus spread during four different periods per season, succeeded with leaf roll but not with virus Y.

In 1957, 1958 and 1961 leaf-roll virus spread mostly before mid-July, very little between mid-July and early August, but a little more from early August to the season's end. In 1959, when the summer was exceptionally fine, more virus spread during July. Four sprays with persistent aphicides: (1) when 50% of the crop has emerged from the ground; (2) 10 days later; and (3) and (4) at fortnightly intervals, will prevent leaf-roll virus spreading within a potato crop until the end of July and in most seasons will therefore prevent almost all spread; the earliest sprays are usually the most important. Systemic soil insecticides applied to prevent leaf-roll virus spreading should make the plants lethal to aphids as early as possible.

Little was learned about the time of spread of virus Y, because in the experimental conditions the insecticides did not prevent its spread.

Further evidence was obtained that leaf-roll virus is spread within crops mostly by alatae colonising the potatoes in spring and early summer.

9.8 ELLIOTT, M. (1964) The pyrethrins and related compounds. III. Thermal isomerization of *cis*-Pyrethrolene and its derivatives. *J. chem. Soc.* 888–892.

When *cis*-pyrethrolone and related compounds are heated new isomers are formed; these have *trans,cis*-diene side-chains in conjugation with the cyclopentenolone ring. *trans*-Pyrethrolone and compounds with mono-olefinic side-chains do not change in this way under the same conditions.

The infrared and ultraviolet spectra of the new, cross-conjugated isomers and of their ketonic derivatives are described and discussed.

9.9 ELLIOTT, M. (1964) The pyrethrins and related compounds. IV. The ultraviolet absorption of the conjugated *cis*-Pentadiene in pyrethrolone. *J. chem. Soc.* 1854–1855.

The ultraviolet absorption of pyrethrolone, purified as its crystalline monohydrate, and of its derivatives, were measured to determine the absorption of the diene in these compounds. The absorption of the diene in *cis*-pyrethrolone (mean value, ε 21,300) is less intense than in *trans*-pyrethrolone (ε 23,200–25,600) but more than found earlier.

9.10 ELLIOTT, M. (1964) The pyrethrins and related compounds. V. Purification of (+)-Pyrethrolone as the monohydrate, and the nature of "pyrethrolone-C". *J. chem. Soc.* 5225–5228.

(+)-Pyrethrolone forms a crystalline monohydrate from which the pure alcohol is obtained for the first time. The properties of the pure compound indicate that the hitherto unidentified pyrethrolone-C is pyrethrolone contaminated with thermally isomerised material.

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9.11 (GODIN, P. J., INGLIS, H. S.) & STEVENSON, J. H. (1964) The insecticidal activity of fresh and dry pyrethrum flowers. *J. Sci. Fd Agric.* (In the press.)

To determine whether any insecticidal activity is lost when pyrethrum flowers are dried in the mildest conditions, acetone extracts of fresh flowers and of flowers dried in the cold over silica gel were compared by gas–liquid chromatography and by biological assay. The first method showed no effect of drying on the amounts of the known insecticidal constituents, and the second that activity was not diminished. Tests on extracts of pyrethrum flowers dried at various temperatures showed no significant change in composition or activity when flowers were dried at temperatures below 80° C, but at 120° C there was a significant loss.

9.12 (GODIN, P. J.), SAWICKI, R. M. & STEVENSON, J. H. (1964) The insecticidal activity of jasmolin II and its isolation from pyrethrum (*Chrysanthemum cinerariaefolium* Vis.). *J. econ. Ent.* (In the press.)

The isolation and the insecticidal activity of jasmolin II, 4′,5′-dihydropyrethrin II, a new constituent of pyrethrum (*Chrysanthemum cinerariaefolium* Vis.) are described. Jasmolin II was nearly as toxic as cinerin II against *Musca domestica* L.; both were about one-quarter as toxic as a commercial pyrethrum extract. With a synergist, piperonyl butoxide (1 part insecticide/8 parts synergist (w/w)) jasmolin II was considerably less toxic than either pyrethrum extract or cinerin II. Jasmolin II was about $\frac{1}{200}$ as toxic as pyrethrum extract against *Tribolium castaneum* Herbst., $\frac{1}{17}$ as toxic against *Aedes aegypti* L. and *Phaedon cochlaeriae* F., about $\frac{1}{14}$ as toxic against *Daphnia magna* Straus. and $\frac{1}{4}$ as toxic against *Tenebrio molitor* L.

9.13 GRIFFITHS, D. C. & BARDNER, R. (1964) Organophosphorus and carbamate insecticides as soil treatments for the control of wireworms. *Ann. appl. Biol.* **54**, 241–254.

Laboratory methods are described for testing soil insecticides against wireworms, and results reported with some organophosphorus and carbamate compounds tried as possible alternatives to chlorinated hydrocarbons. The most promising compounds were thionazin, O-ethyl S-*p*-tolylethylphosphonodithioate (Bayer 38156) and fenthion, and these were tested in a field trial with cereals, on land severely infested with wireworms: the compounds were applied to the soil as sprays at 2·7 lb/acre active ingredient before the crop was drilled. Fenthion was ineffective, but thionazin and Bayer 38156 each increased yields significantly, and the increases were associated with diminished wireworm populations.

9.14 LORD, K. A. & BURT, P. E. (1964) Effect of temperature on water solubility of phorate and disulfoton. *Chemy Ind.* 1262–1263.

The solubility of phorate and disulfoton in water was measured by extracting the insecticide into dichloromethane and comparing by a gas chromatograph with extracts of dichloromethane from aqueous standard solutions of insecticides.

Solubility ranged between 10 and 20 ppm between temperatures of 5° and 25° C.

9.15 LORD, K. A. & SOLLY, S. R. B. (1964) Effect of insecticides, especially diazinon, on the amino acids of adult houseflies *Musca domestica*. *Biochem. Pharmac.* **13**, 1341–1349.

1. The amounts of individual free amino acids in different strains of housefly can differ. These differences are not related to selection by or resistance of the flies to Diazinon.

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2. The amounts of free amino acids in houseflies change with changing age and nutritional status.
3. Poisoning changed the amino acids of houseflies. Each poison produced characteristic effects, but the changes caused by diazinon resembled those of oxygen excess and of poisoning by dinitrophenol. Changes caused by the pyrethrins resemble those of oxygen lack and of poisoning by cyanide and fluoracetate.
4. Changes in the amino acids of houseflies caused by diazinon suggest that organophosphorus poisons may affect the metabolism of fats or carbohydrates, in addition to inhibiting cholinesterase of the nervous system.

9.16 PHILLIPS, F. T. (1964) The aqueous transport of water-soluble nematicides through soils. I. The sorption of phenol and ethylene dibromide solutions and the chromatographic leaching of phenol in soils. *J. Sci. Fd Agric.* **15**, 444–450.

The sorption isotherms of phenol and ethylene dibromide in aqueous solutions with sand loams, silt loams and peaty soils are linear. The degree of sorption shows correlations with the physical characteristics of the soils, and sorption coefficients depend mainly on the soil type rather than on the solute used.

The percolation of phenol in aqueous solution through different soil types follows a chromatographic process, and agrees well with a theory of chromatography.

9.17 PHILLIPS, F. T. (1964) The aqueous transport of water-soluble nematicides through soils. II. The movement of phenol solutions at a constant percolation rate through a soil profile. *J. Sci. Fd Agric.* **15**, 450–458.

Phenol is used as a test chemical to simulate a water soluble nematicide.

The concentration-time product (C.T.P.) of phenol solutions percolated through water-saturated soil profiles remains approximately constant at all depths, the band width broadening gradually.

When percolated through weakly sorptive soils (sands, silts) which have similar linear sorption isotherms, the rate of leaching of the phenol band is directly proportional to the percolation rate and the C.T.P. is inversely proportional to the percolation rate. For highly sorptive soils (peats) with linear sorption isotherms, other factors have to be introduced.

Winter rain is enough in this country to leach the phenol band through 1–1½ ft depth, depending on the soil type.

9.18 PHILLIPS, F. T. (1964) The aqueous transport of water-soluble nematicides through soils. III. Natural factors modifying the chromatographic leaching of phenol through soil. *J. Sci. Fd Agric.* **15**, 458–463.

A band of phenol solution moves upwards through the soil layers when the surface dries.

Surface impaction by raindrops and temperature changes affect the percolation rate, and hence the leaching rate of phenol.

Bacteria in soil sometimes decompose phenol.

9.19 SAWICKI, R. M. (1964) Similarity in response to diazinon, dieldrin and pyrethrum extract by allatectomized and normal house flies (*Musca domestica* L.). *Bull. ent. Res.* (In the press.)

Because resistance of houseflies to diazinon increases with increase in age, and could be correlated with the development of the ovaries, female houseflies allatectomised less than 12 hours after emergence, to prevent the ovaries developing, and normal flies were treated 3 days after emergence with measured

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drops of diazinon, dieldrin and pyrethrum. Diazinon and dieldrin killed similar proportions of allatectomised and normal flies, and allatectomy had no effect on the increase in resistance to diazinon on ageing. Pyrethrum killed more normal flies than operated flies, but the differences in the proportions of flies killed was probably not significant. Allatectomy prevented the maturation of the ovaries and the absorption of the fat-body, as it does in other *Calypterae*. A rapid technique to immobilise the flies and remove the corpus allatum complex (corpus allatum and corpus cardiacum) is described.

9.20 SAWICKI, R. M. & ELLIOTT, M. (1964) Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. VI. Relative toxicity of pyrethrin I and pyrethrin II against four strains of house flies. *J. Sci. Fd Agric.* (In the press.)

Because various workers disagree about the relative toxicities of pyrethrin I and II to houseflies, freshly reconstituted samples of these esters were tested against 4 strains of houseflies. Pyrethrin II was 1·21–1·50 times more toxic than pyrethrin I 24 hours after treatment, and again 1·09–1·54 times more toxic 48 hours after treatment. The strain of flies and the method of immobilising the insects before treatment (CO_2 or chilling) had little effect on the relative toxicity of the two esters. Two strains, resistant to organophosphorus insecticides, were very strongly resistant to knock-down, but not to kill by the pyrethrins. The two esters were stable for 3 months when stored as 5% w/v solutions in darkness at −20°; only pyrethrin II lost some of its insecticidal activity (23%) when left in acetone solution in daylight for 5 days at 15–20°.

9.21 SAWICKI, R. M. & FARNHAM, A. W. (1964) A dipping technique for selecting house flies for resistance to insecticides compared with a measured drop technique. *Bull. ent. Res.* (In the press.)

A dipping technique is described that gives reproducible results but entails less work than most methods commonly used to select houseflies for resistance. About 2,000 flies of both sexes, less than 24 hours old, are dipped in 100 ml of a 70% v/v solution of acetone and water containing diazinon in a 9-cm sintered-glass Buchner funnel for 3 minutes. The solution is then sucked off and, after draining for 3 minutes in the funnel, the flies are transferred into plastic cups, fed and checked for death on the next day. The survivors are released into breeding cages. The variations in pick-up by individual flies, measured colorimetrically with a dye, were small (Standard Error less than 20%), and the reproduction in kill between individual dishes was as good as by topical application of measured drops. Up to 2,000 flies could be treated at one time.

Dipping gave steeper log-probit regression lines, the LD50s and resistance factors of resistant strains were smaller than by treatment with measured drops. With DDT-resistant flies normal ld–p lines were obtained with dipping, whereas topical application gave compound ld–p lines. It should be possible to increase the resistance of houseflies by dipping where increasing the dose applied by topical application does not increase kill.

9.22 SAWICKI, R. M. & GREEN, G. (1964) Changes in the susceptibility of susceptible and resistant adult house flies (*Musca domestica* L.) to diazinon with age. *Bull. ent. Res.* (In the press.)

Both in a susceptible and a diazinon-resistant strain of houseflies, adults of both sexes were most susceptible to diazinon immediately after emerging from the pupae. The resistance increased for 2 days after emergence and remained steady for the next 3 days. The increase in resistance was proportionally greater with the resistant strain. In both strains the two sexes were equally susceptible

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to diazinon during the first day, but later the females were more resistant than the males. The resistance factor increased with age from 15, 2 ± 2 hours after emerging to about 60 3 days later, and was least immediately after emergence. There was no direct correlation between changes in resistance and changes in the weight of the flies or ageing. The resistance factor to diazinon should be measured not earlier than 3 days after emergence to obtain reproducible values. The removal of the ovaries in flies less than 1 day old did not affect the increase in resistance with age.

9.23 WAY, M. J. & BANKS, C. J. (1964) Natural mortality of eggs of the black bean aphid, *Aphis fabae* Scop., on the spindle tree, *Euonymus europaeus* L. *Ann. appl. Biol.* **54**, 255–267.
For summary, see No. 10.35.

Entomology Department

BOOK

10.1 EDWARDS, C. A. & HEATH, G. W. (1964) *The principles of agricultural entomology*. London: Chapman and Hall, 418 pp. 36 plates.

GENERAL PAPERS

10.2 COCKBAIN, A. J. & HEATHCOTE, G. D. (1965) Transmission of sugar beet viruses in relation to the feeding, probing and flight activity of alate aphids. *Proc. XII int. Congr. Ent.* (In the press.)

10.3 EDWARDS, C. A. (1964) Factors affecting the persistence of insecticides in soil. *Soils & Fert.* **27**, 451–454.

10.4 EDWARDS, C. A. (1965) Effects of pesticide residues on soil invertebrates and plants. In: *Ecology and the Industrial Society. Symposium of the British Ecological Society*, Swansea 1964. Oxford: Blackwell Scientific Publications, pp. 239–261.

10.5 FRENCH, R. A. (1965) Long distance movement of two migrant Lepidoptera in relation to synoptic weather conditions. *Proc. 3rd int. Congr. Biomet. Pau., 1963*. (In the press.)

10.6 FRENCH, R. A. (1965) Long range dispersal of insects in relation to synoptic meteorology. *Proc. XII int. Congr. Ent.* (In the press.)

10.7 HEATH, G. W. (1964) Biology and climate change. *New Scient.* **24**, 347–348.

10.8 HEATH, G. W. (1965) The part played by soil animals in soil formation. In: *Experimental pedology*. ed. D. V. Crawford. London: Butterworths, 236–243.

10.9 JOHNSON, C. G. (1963) Physiological factors in insect migration by flight. *Nature, Lond.* **198**, 423–427.

10.10 JOHNSON, C. G. (1964) The migration and dispersal of aphids and the dissemination of plant viruses. *Biology hum. Affairs* **29** (3), 11–16.

10.11 JOHNSON, C. G. (1965) The progress of research at Rothamsted on aerial migrations of insects. *Proc. 3rd int. Congr. Biomet. Pau., 1963*. (In the press.)

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10.12 JOHNSON, C. G. (1965) Migration. In: *Physiology of the Insecta*. vol. 2. ed. M. Rockstein. New York: Academic Press. (In the press.)

10.13 JUDENKO, E. (1965) Some methods of assessing crops loss caused by pests. *Proc. XII int. Congr. Ent.* (In the press.)

10.14 LEWIS, T. (1965) The effects of shelter on the distribution of insect pests. *Sci. Hort.* (In the press.)

10.15 LEWIS, T. & HURST, G. W. (1965) Take-off thresholds in Thysanoptera and the forecasting of migratory flight. *Proc. 3rd int. Congr. Biomet. Pau., 1963*. (In the press.)

10.16 LEWIS, T. & TAYLOR, L. R. (1965) Diurnal flight periodicity and insect migration. *Proc. 3rd int. Congr. Biomet. Pau., 1963*. (In the press.)

10.17 TAYLOR, L. R. (1965) The mode of action of weather on insect flight. *Proc. 3rd int. Congr. Biomet. Pau., 1963*. (In the press.)

10.18 TAYLOR, L. R. (1965) The effect of weather on the height of flight of insects. *Proc. 3rd int. Congr. Biomet. Pau., 1963*. (In the press.)

10.19 TAYLOR, L. R. (1965) A natural law for the spatial disposition of insects. *Proc. XII int. Congr. Ent.* (In the press.)

10.20 TAYLOR, L. R. & LEWIS, T. (1965) Insect flight rhythms. *Sci. Amer.* (In the press.)

RESEARCH PAPERS

10.21 (ALDRICH, D. T. A.), GIBBS, A. J. & TAYLOR, L. R. (1965) The incidence of bean leaf-roll virus in some varieties of field bean (*Vicia faba* L.) *Pl. Path.* **14**, 11–14.
(For summary see No. 7.9.)

10.22 BANKS, C. J. & MACAULAY, E. D. M. (1965) The ingestion of nitrogen and solid matter from *Vicia faba* by *Aphis fabae* Scop. *Ann. appl. Biol.* **55**. (In the press.)

Aphis fabae was reared on two varieties of field bean (*Vicia faba*) on which it differs in fecundity; the total amounts of solids and nitrogen ingested and assimilated during larval life and during the reproductive and early post-reproductive life were estimated. Larvae ingested 0·7–0·8 mg solids containing 0·02–0·03 mg nitrogen in 7 days of larval life; they ingested and excreted more solids and nitrogen from one variety than the other. Adult virginoparae ingested 4·4–4·9 mg solids containing 0·08–0·09 mg nitrogen during the reproductive life of 3 weeks; they ingested almost equal amounts of solids from each variety and, like the larvae, assimilated about 20%; their dry weights increased slowly during reproductive life and rapidly during early post-reproductive life. Adults assimilated 70% and larvae 50% of the nitrogen ingested and, although larvae assimilated and excreted significantly more nitrogen on one variety, the adults assimilated more nitrogen on the other variety, on which they produced significantly more larvae. The nitrogen content of the sap of both varieties seems more than adequate for the aphids to grow and reproduce, and did not determine fecundity.

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10.23 CALNAIDO, D, FRENCH, R. A. & TAYLOR, L. R. (1965) Low altitude flight of *Oscinella frit* L. (Diptera: Chloropidae). *J. Anim. Ecol.* **34**, 45–61.

The density of *O. frit* was measured by a vertical series of suction traps from plant-top to tree-top height in 1961 and 1962 above grass and oats. Parts of the profile of log insect density in relation to log height above 2·5 m and below 0·5 m have a negative gradient, and between these two heights the discontinuity varied throughout the trapping season. This discontinuity is peculiar to *O. frit*, and could not be detected in other insects trapped at the same time. Above 0·5 m the gradient was independent of ground cover and the profiles were similar for both sexes. The take-off of newly emerged adults is the chief factor affecting the number of frit in the air, suggesting that the flies quickly leave the crop or, if they remain, soon cease to fly. Increase in rainfall, wind and take-off lowered the mean height of flight, those factors accounting for 63% of the variance of the gradient of aerial density in the tiller generation; only wind speed significantly affected the gradient in the panicle generation.

10.24 EDWARDS, C. A. (1965) Some side-effects resulting from the use of persistent insecticides. *Ann. appl. Biol.* **55**. (In the press.)

Some insecticides stimulate or retard the growth of plants. Tomatoes, cucumbers and beans are the most sensitive crops, and BHC is the most phytotoxic hydrocarbon, with dieldrin the least and aldrin and DDT intermediate. Aldrin, dieldrin and DDT have sometimes increased pest attack. Of the chlorinated hydrocarbon insecticides, only chlordane and heptachlor have affected earthworms. Of the other groups of animals different groups are affected differently by insecticides. Organophosphorus insecticides have had much less effect on soil animals than chlorinated hydrocarbons.

10.25 FRENCH, R. A. (1964) Migration Records 1962. *Entomologist* **97**, 121–128.

10.26 FRENCH, R. A. (1965) Migration Records 1963. *Entomologist* **98**. (In the press.)

10.27 HARIRI, G. EL. (1965) Records of nematode parasites of *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae). *Entomologist's mon. Mag.* (In the press.)

A new species of *Howardula* (Tylenchida, Allantonematidae) has been found in the body cavity of *A. bipunctata*.

10.28 HEATH, G. W. (1965) An improved method for separating arthropods from soil samples. *Lab. Pract.*, **14**, 430–432.

An improved version of the Salt and Hollick method of separating arthropods from soil, uses an organic solvent mixture of Dekalin and carbon tetrachloride to float off the animals and separate them from the soil and vegetation by an overflow apparatus or a separating funnel.

10.29 HEATH, G. W. & KING, H. G. C. (1964) Litter breakdown in deciduous forest soils. *Rep. 8th. int. Congr. Soil Sci.* Bucharest. (In the press.)

Some leaves, particularly of oak and beech, last for about 3 months after falling before soil animals feed on them. Leaf litter was extracted in petroleum ether and 50% methanol, and the polyphenols in the extract determined by paper chromatography. The less the concentration of gallic and protocatechuic acids, the more readily soil animals fed on the leaves.

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10.30 HEATHCOTE, G. D. & COCKBAIN, A. J. (1964) Transmission of beet yellows virus by alate and apterous aphids. *Ann. appl. Biol.* **53**, 259–266. (For summary see No. 16.8.)

10.31 KNUTSON, L. V., STEPHENSON, J. W. (& BERG, C. O.) (1965) Biology of a slug-killing fly, *Tetanocera elata* (Diptera, Sciomyzidae). *Proc. malac. Soc. Lond.* **36**, (4). (In the press.)

There are more than 100 species of Sciomyzidae, and larvae of all those that have been reared to date feed only on aquatic and terrestrial gastropods. Several species apparently are the only insects known to have an obligatory trophic relationship with slugs. *Tetanocera elata* feeds on mucus under the mantle of living *Agriolimax* slugs during the first part of larval life. The mature larva is a predator, attacking and killing slugs of several genera.

10.32 LEWIS, T. (1965) The species, aerial density and sexual maturity of Thysanoptera caught in mass flights. *Ann. appl. Biol.* **55**. (In the press.)

The commonest Thysanoptera in mass flights between ground level and 1,000 ft in S.E. England are females of species dwelling on grasses and cereals. Individuals with immature ovaries probably disperse over the greatest distances. Aerial densities as large as 60,000 thrips/10^6 cu ft were recorded.

10.33 LEWIS, T. & TAYLOR, L. R. (1964) Diurnal periodicity of flight by insects. *Trans. R. ent. Soc. Lond.* **116**, 393–479.

An account is given of the diurnal flight periodicity of about 400 taxa based on data obtained from about half a million specimens collected in suction traps in various localities, mainly in Southern England. The effect of light intensity and the relation of size and colour to the time of flight are discussed. The evolution of night flight in certain orders is considered.

10.34 LOWE, H. J. B. & TAYLOR, L. R. (1965) Population parameters, wing production and behaviour in red and green *Acyrthosiphon pisum* (Harris) (Homoptera: Aphididae). *Ent. exp. & appl.* (In the press.)

A red strain of *A. pisum* produced more alatae, was more fecund, reproduced more rapidly but did not live as long as a green strain; it was also disturbed more easily, responding only to moist, not dry currents of air, and it was less active in finding the new growth on bean plants.

10.35 WAY, M. J. & BANKS, C. J. (1964) Natural mortality of eggs of the black bean aphid, *Aphis fabae* Scop., on the spindle tree, *Euonymus europaeus* L. *Ann. appl. Biol.* **54**, 255–267.

Egg mortality of *Aphis fabae* Scop. ranged from 18 to 73% on individual bushes of *Euonymus europaeus* L. at different sites in Hertfordshire during the winters of 1958–59 and 1959–60. Field and laboratory experiments indicated that the average mortality is unlikely to exceed about 40% and is probably relatively unimportant in limiting subsequent increase to pest density. Winter temperatures in Southern England do not harm eggs, except perhaps at hatching time. Some eggs are destroyed by Anthocoridae and by birds. Others either fail to develop or develop fully but fail to hatch, even when the weather is apparently favourable and natural enemies are absent.

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Bee Department

General Papers

11.1 Butler, C. G. (1964) Control of behaviour in the honeybee colony. *Proc. R. Instn Gt. Br.* **40** (No. 182), 82–91.

11.2 Free, J. B. (1964) Honeybees play an important role in orchard fruit set. *Comml Grow.* April, 860–862.

11.3 Free, J. B. (1964) The allocation of duties among worker honeybees. *Anim. Behav.* **12**, 389–390.

Research Papers

11.4 Bailey, L. & Gibbs, A. J. (1964) Infection of bees with acute paralysis virus. *J. Insect. Path.* **6**, 395–407.

Acute bee paralysis virus (ABPV) occurs commonly in adult bees (*Apis mellifera* L.) in Britain. The amount of the virus in different bees differs, as does the proportion of infected bees in different colonies. No organ or part of a bee, or faeces, was found to be invariably free from virus. Bees fed by other bees that had been infected with pathogenic doses of ABPV, or with food containing up to 10^{10} particles of ABPV, did not become obviously diseased, but the virus content of their tissues temporarily increased. However, bees fed with at least 10^{11} ABPV particles each, or injected with 10^{2} particles, became diseased and died, and their abnormal behaviour was possibly attributable to the observed changes in their brains.

Bombus spp. are susceptible to ABPV, and many apparently healthy individuals contain the virus. Several species of other genera of insects were unaffected by the virus.

11.5 Bailey, L., Gibbs, A. J. & Woods, R. D. (1964) Sacbrood virus of the larval honeybee (*Apis mellifera* Linnaeus). *Virology* **23**, 425–429.

Extracts of honeybee larvae suffering from sacbrood contained many isometric particles that were about 28 mμ in diameter. When extracts of purified preparations of the particles were put into the food of healthy larvae these developed sacbrood. The particles, which were not found in comparable extracts of healthy larvae, resemble those of acute bee paralysis virus, but cross-infection and serological tests failed to show any relationship between the two viruses. Isolates of sacbrood virus from Europe and North America appear to be identical.

11.6 Butler, C. G., (Callow, R. K. & Chapman, J. R.) (1964) 9-Hydroxydec-*trans*-2-enoic acid, a pheromone stabilizing honeybee swarms. *Nature, Lond.* **201**, 733.

A swarm of honeybees is prevented from dispersing by an odour from the queen. This odour is that of the 9-hydroxydecenoic acid produced in the queen's mandibular glands.

11.7 Butler, C. G. & Fairey, E. M. (1964) Pheromones of the honeybee: biological studies of the mandibular gland secretion of the queen. *J. apic. Res.* **3** (2), 65–76.

Several substances present in heads of queen honeybees were tested as sex attractants for drones and as stabilisers of the swarm cluster. The whole of the odour of a queen that attracts drones is produced in her mandibular glands, and it can be accounted for by 9-oxodecenoic acid alone. Another pheromone, 9-hydroxydecenoic acid, is slightly attractive to drones; it is responsible for

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stabilising swarm clusters. New evidence indicates that few, if any, drones are attracted from long distances by queens, and that the wind speed influences both the number of drones flying and the height at which they fly. Because a drone's visual acuity is small, he must get within 1 m of a queen before he can see her. Her scent enables him to do this. It is, however, most unlikely that he follows a scent gradient, and an alternative method of using a queen's scent to find her is discussed.

Drones appeared to be distributed uniformly around their hives, their numbers decreasing as distance from the hive increased. Few ventured more than 3 km from their hives in the experiments; they were found up to 800 m out to sea. No evidence was obtained that drones normally congregate in particular places, and it is considered unlikely that they do so.

11.8 FREE, J. B. (1964) The behaviour of honey bees on sunflowers (*Helianthus annus* L.). *J. appl. Ecol.* **1**, 19–27.

Honeybees collecting nectar from sunflowers often become heavily dusted with pollen; some bees pack this into their corbiculae, whereas others always discard it. Bumblebees are less inclined than honeybees to collect pollen. A few honeybees scrabble over the male flowers for pollen without collecting nectar on some visits, but collect nectar on others, and, when they do so, tend also to collect pollen loads more often than bees that had never deliberately sought pollen.

11.9 FREE, J. B. (1964) Comparison of the importance of insect and wind pollination of apple trees. *Nature, Lond.* **201**, 726–727.

Experiments using small apple trees enclosed in cages, and emasculated flowers on mature trees, gave ample evidence of insect pollination but none of wind pollination.

11.10 FREE, J. B. & SIMPSON, J. (1963) The respiratory metabolism of honeybee colonies at low temperatures. *Ent. exp. & appl.* **6**, 234–238.

Honeybee colonies exposed to temperatures between 20° and −39° C produced less CO_2 at 10° C than at higher or lower temperatures.

11.11 FREE, J. B. & SPENCER-BOOTH, Y. (1964) The effect of distance from pollinizer varieties on the fruit set of apple, pear and sweet cherry trees. *J. hort. Sci.* **39**, 54–60.

In a dwarf-pyramid apple orchard rows of Cox's Orange Pippin adjacent to rows of James Grieve had greater initial and final fruit sets than rows between other Cox rows. Flowers on the south sides of the trees tended to set more fruit than those on the north.

In a sweet-cherry orchard containing a block of five rows of Early Rivers with pollinizer rows on each side most fruit was set on the two outside rows and least in the centre row. Trees in the outside rows set more fruit on their sides facing the pollinizers than on their far sides. In another sweet-cherry orchard Frogmore trees set more fruit on their south sides than elsewhere.

In a dwarf-pyramid orchard of Comice pears the trees with one graft of Conference (every tenth tree) set more fruit than trees without a graft. However, the fruit set on dwarf and standard Conference trees (two orchards of each) did not differ with their distance from pollinizers.

11.12 FREE, J. B. & SPENCER-BOOTH, Y. (1964) The foraging behaviour of honeybees in an orchard of dwarf apple trees. *J. hort. Sci.* **39**, 78–83.

Individual bees tend to be constant to the type of food they are collecting from apple flowers, but most will alter their behaviour. This adaptability probably

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mostly accounts for changes in the ratio of nectar-gatherers to pollen-gatherers in orchards.

Flowers of James Grieve and Cox's Orange Pippin are equally attractive, and bees readily move from one variety to the other; flowers of Bramley's Seedling are less attractive.

During any one foraging trip most bees probably visit the flowers along about 10 ft only of a continuous row, and relatively few move from one row to another. To increase bee pollination, polliniser trees should therefore be planted at intervals of not more than 10 ft in the same rows as trees of the main variety.

11.13 SIMPSON, J. (1963) The source of the saliva honeybees use to moisten materials they chew with their mandibles. *J. apic. Res.* **2**, 115–116.

The saliva bees use when chewing is alkaline and does not char when heated. It is probably labial gland secretion, which has the same properties. It cannot come from the mandibular glands, which have a strong acid secretion, or from the hypopharyngeal glands, which secrete enzymes and food for larvae.

11.14 SIMPSON, J. (1964) The mechanism of honeybee queen piping. *Z. vergl. Physiol.* **48**, 277–282.

Queens breathed in and out while producing continuous sounds and could pipe with all their spiracles blocked, so the sound cannot be produced by air entering or leaving the spiracles. During sound production the flight motor is operated with the wings folded, and the resulting vibrations of the thorax are radiated partly by the substratum, against which the thorax is pressed.

11.15 SIMPSON, J. (1964) Dilution by honeybees of solid and liquid food containing sugar. *J. apic. Res.* **3**, 37–40.

Foods containing 50% or more sugar were diluted by bees during ingestion. The bees produced more dilute solutions from dry sugar, invert sugar-candy and granulated honey than from liquid honey. Thus, colonies fed solid foods must collect water to add to the food and then evaporate it to bring the food to the concentration of honey when they store it in cells.

11.16 SIMPSON, J. & FAIREY, E. M. (1964) How efficiently can wax be extracted from old brood combs by simple methods? *Bee World* **45**, 99–103.

Solvent extraction showed that old brood combs contain more wax than new combs, but also much insoluble material from which the wax is difficult to separate. Solvent extraction of the residues from domestic methods of wax extraction showed that only pressing gave reasonably effective extraction, and the other methods could fail to get any wax out of very old combs.

11.17 SIMPSON, J. & RIEDEL, I. B. M. (1964) The emergence of swarms from *Apis mellifera* colonies. *Behaviour* **23**, 140–148.

Many of the bees that returned to their old site when part of their colony was moved a short distance went with the swarm when their colony subsequently swarmed, and remained with the swarm when it was hived a short distance away. Evidently, swarming changed the behaviour of the bees that swarmed so that they were less inclined to return to their old position.

Bees added to a crowded colony while it was swarming went with the swarm, but bees added to an uncrowded colony shortly before it swarmed did not. Colonies deprived of their hives and combs behaved like swarms and absconded. Bees from an absconding colony could make another hiveless and combless colony held close to the first abscond immediately.

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11.18 SIMPSON, J. & RIEDEL, I. B. M. (1964) Discharge and manipulation of labial gland secretion by workers of *Apis mellifera* (L.) (Hymenoptera: Apidae). *Proc. R. ent. Soc. Lond.* (A), **39**, 76–82.

Bees feeding on dry sugar alternately discharge saliva on to the food and suck up the resultant solution. Movement of saliva downwards and food upwards depends on capillarity and the movement of the tongue in and out of the tube formed by the maxillae and labial palps. The tongue's capacity to hold liquid is increased when it is stretched by its rod so that its bristles become erect. The tongue is pulled in between the maxillae and labial palps by retraction of the ligula into the base of the prementum. This involves retraction both of the ligula arms and of the rod, but the mechanism allows these movements to be independent enough for the tongue to move either in or out with its bristles either erect or flat. Further retraction of the rod than is required to flatten the bristles makes the tongue bend backwards to its resting position.

The salivary pump is dilated by muscles attached to its dorsal surface and flattened by its own elasticity. The function of the muscles attached to its edge is probably to initiate retraction of the ligular arms. The pump has no inlet valve, but an inflated part of the hypopharyngeal surface is probably an outlet valve that, together with friction in the salivary ducts, makes pumping possible. Saliva can be discharged with the ligula almost fully retracted. This enables it to be supplied to the mandibles during chewing.

Statistics Department

GENERAL PAPER

12.1 LEECH, F. B. (1965) *Statistics*. Contribution to the *International encyclopaedia of veterinary medicine*. Edinburgh: Green & Son Ltd. (In the press.)

RESEARCH PAPERS

12.2 BOYD, D. A. & FRATER, A. (1965) Analytical methods for potassium and their correlations with crop response. *Bull. Minist. Agric. Fish Fd.* (In the press.)

Results are given of investigations made by the N.A.A.S. Soil Chemists' Conference to compare the value of different methods of soil analysis in predicting crop responses to potassium fertiliser. Even for crops responsive to K, none of the methods accounted for more than about one-third of the variance of the K responses. For the less responsive crops most of the methods tested were almost completely ineffective.

12.3 CLARKE, R. T. & (SMITH, C. W. R.) (1964) The residual effects of potassium fertilisers on yields of arable crops: Preliminary results of five rotation experiments. *Expl. Husb.* (In the press.)

Five long-term experiments on the residual effects of sulphate or muriate of potash on a four-course rotation of crops (usually potatoes, barley, roots, legume) were started at the N.A.A.S. Experimental Husbandry Farms in the early 1950s. A report covering the years up to 1961 is presented.

At one of the farms, Boxworth, even direct application of the K fertiliser had little effect. At the other farms all crops showed both direct and residual effects. In general, the results were consistent with the percentage equivalent (50% for the first and 25% for the second year) given in the tables of residual

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values published by the Ministry of Agriculture. But potatoes and clover at Trawscoed and potatoes at Bridget's showed smaller residual responses.

The treatment rates for potatoes are too low (except at Bridget's) for reliable estimation of the dressings giving maximum total profit over all crops. It is, however, clear that at the relatively low rates tested a given amount of K fertiliser is better all applied to responsive crops of high value than in equal dressings to all crops.

12.4 (Cranbrook, The Earl of & Barrett, H.) Appendix by Yates, F. (1964) Observations on noctule bats (*Nyctalus noctula*) captured while feeding. *Proc. zool. Soc. Lond.* (In the press.)

In the capture–recapture method of assessing wild populations the development of trap or net shyness complicates the deductions. To establish that net shyness did not develop in these observations the intervals between successive captures of individual bats were tabulated, subdivided according to the number of captures per bat. To obtain valid overall means of successive intervals from this table it is necessary to fit constants in order to allow for unoccupied cells.

12.5 (Delany, M. J.) & Healy, M. J. R. (1964) Variation in the long-tailed field-mouse (*Apodemus sylvaticus* (L.)) in North-West Scotland. II. Simultaneous examination of all characters. *Proc. R. Soc.* B **161**, 200–207.

A number of measurements were taken on samples of *Apodemus* spp. from two places in Western Scotland and several of the nearby islands. These were analysed by the calculation of canonical variates. This indicated that animals from Lewis, Mull and Raasay resembled those from the mainland localities; animals from North and South Uist and Barra were similar; animals from Rhum were notably larger than the others, and those from Colonsay were intermediate between those from Rhum and those from North and South Uist.

12.6 (Douglas, J. W. B.) & Simpson, H. R. (1964) Height in relation to puberty, family size and social class: a longitudinal study. *Milbank meml Fund q. Bull.* **42**, 20–35.

In a national sample 1,557 boys and 1,456 girls were measured at 7, 11 and 15 years. Using a statistical technique for handling non-orthogonal data, their heights at these ages are related to the social and educational background of their parents, the number of brothers and sisters, and the age at onset of puberty.

12.7 (Douglas, J. W. B., Ross, J. M.) & Simpson, H. R. (1965) The relation between height and measured educational ability in schoolchildren of the same social class, family size and stage of sexual development. *Hum. Biol.* (In the press.)

The correlations between heights and measured ability of 2,864 children from the National Survey sample have been calculated after grouping by sex, social class, family size and stage of puberty. These social and biological factors, whether considered singly or together, do not influence consistently the size of the correlation between height and measured ability in either the primary or the secondary school years.

12.8 Healy, M. J. R. (1964) Descriptive uses of discriminant functions. *Proceedings of Conference on Mathematics and Computers in Medicine.* (In the press.)

When multiple measurements are taken on a number of individuals falling into several groups it is often required to study how the differences between the

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groups are reflected by the measurements. It is possible to construct a weighted sum of the original measurements which gives the best summary of the grouping, in the sense that its variance between groups is a maximum. If this single compound measurement does not account for all the between-group differences a second compound can be chosen which maximises the between-group variance among all compounds which are orthogonal to the first. This technique is described with some details of ways of dealing with special circumstances, and applications to physical anthropology, zoology and human biology are discussed.

12.9 HEALY, M. J. R. (1965) A note on the use of procedures. *Communs Ass. comput. Mach.* (In the press.)

In many programming languages the correspondences between formal and actual parameters are set up at each procedure call. Often these correspondences do not change over several successive calls, and the procedure could be used more efficiently if the setting-up process and entry to the procedure itself could be called for separately.

12.10 (HOWELL, D., WILSON, C. D.) & VESSEY, M. P. (1964) A survey of the incidence of mastitis in dairy cows in the Reading area. *Vet. Rec.* **76**, 107–112.

During 1958–59 visits were made to the 141 farms with a milking herd of more than 20 cows situated within a 10-mile radius of Reading. For each cow details of breed, lactation number and date of last calving were recorded, the udder examined and a whole udder milk sample taken. Particulars of the milking machine and its operating conditions were also noted.

The main results were:

1. No relationship was established between milking technique and mastitis, but the small number of farms and lack of variety of machines and operating conditions largely vitiated this part of the survey.
2. The Whiteside test was positive in 36% of samples, and of these almost 70% were graded ++ or more.
3. Only 54% of milk samples were free from recognised pathogens. In all but 17 samples the organisms isolated were *Staph. pyogenes*, *Str. agalactiae*, *Str. uberis* or *Str. dysgalactiae*, either singly or together.
4. The physical appearance of 1·7% of samples was considered to be very abnormal; a further 3·3% contained small clots.
5. Almost 20% of udders had some clinical abnormality, the most frequent of which was an indurated swelling.
6. The correlations between the various laboratory investigations and between clinical abnormalities and laboratory investigations were, in general, low.

12.11 LESSELLS, W. J. & (WEBBER, J.) (1965) The effect of nitrogen on winter wheat. *Expl. Husb.* (In the press.)

The results are summarised of 114 experiments done by members of the National Agricultural Advisory Service between 1957 and 1963 testing the effects of nitrogen on the yields of winter wheat. Averaged over all experiments, a standard dressing of 0·6 cwt N/acre increased yields by 6 cwt/acre. The largest responses were obtained when yields without nitrogen were less than 30 cwt/acre; dressings were then more effective in April than in May. As the yields without nitrogen increased above 30 cwt/acre the average response to nitrogen decreased, and the larger responses were obtained from the later spring application. Lodging occurred frequently on high-yielding sites, especially where large dressings of

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nitrogen were applied early in spring. In general, autumn dressings were less effective than their spring equivalents.

Sites recently ploughed from grass were less responsive than arable sites. For grassland sites dressings of 0·4–0·6 cwt N/acre in May are recommended; after arable cropping April dressings of 0·6 cwt N/acre are recommended on heavy clay soils, and 0·8–0·9 cwt N/acre on other soils; on peaty fen soils, in wet areas and on sites where organic manures were frequently applied, a maximum dressing of 0·4 cwt N/acre should be applied in May.

12.12 LESSELLS, W. J. & (WEBBER, J.) (1965) The effect of nitrogen on spring cereals. *Expl. Husb.* (In the press.)

The results are summarised of 76 experiments done by members of the National Agricultural Advisory Service between 1959 and 1962, comparing the responses of spring barley and wheat to combine-drilled and broadcast nitrogen. For crops sown before mid-April dressings of 0·6 cwt N/acre increased the average grain yields by 9·0 cwt/acre. Responses were small when the spring cereal was sown late or immediately followed grazed kale, and frequently small on sites recently ploughed from grass. When following a series of arable crops the responses of spring barley were large when yields without nitrogen were less than 30 cwt/acre, but decreased as the yields increased above this level.

When yields without nitrogen were less than 25–30 cwt/acre drilled applications of up to 0·6 cwt N/acre produced larger yields of barley than did equivalent broadcast dressings. On more fertile sites yields from broadcast dressings were at least equal to those from drilled applications. In the fewer spring wheat experiments there were no consistent differences between the effects of drilled and broadcast nitrogen.

When the cereal crop is sown late, immediately following grazed kale, or is the first or second crop following a long ley or permanent grass, dressings of 0·3 cwt N/acre for barley and 0·4 cwt N/acre for wheat are recommended. Following a series of arable crops spring barley should receive either 0·6 cwt N/acre drilled or 0·8 cwt N/acre broadcast; spring wheat should receive 0·6 cwt N/acre.

12.13 PATTERSON, H. D. (1965) The factorial combination of treatments in rotation experiments. *J. agric. Sci.* (In the press.)

The paper deals with points arising in the design of factorial schemes for incorporating fertiliser and other treatments in rotation experiments. These schemes make extensive use of fractional replication and confounding, including split-plot confounding. They are complicated by the need to apply some treatments cumulatively and others with levels changed between plots in successive cycles so as to minimise errors due to constant plot differences.

Design keys are used to identify the treatment main effects and rotation differences with particular plot contrasts. The keys exhibit the structure of a design more compactly and clearly than a complete enumeration of identities and confounded contrasts and enable treatment combinations to be generated systematically.

The main points arising in the discussion are illustrated by detailed reference to an experiment comparing the effects of varying some of the crops of a basic rotation.

12.14 (PAYNE, J. M.) & LEECH, F. B. (1964) Factors affecting plasma calcium and inorganic phosphorus concentrations in the cow with particular reference to pregnancy, lactation and age. *Br. vet. J.* **120**, 385–388.

Blood samples were taken from 279 cows in the Compton dairy herds and the mean plasma calcium and inorganic phosphorus concentrations found to be

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10·65 and 5·32 mg/100 ml respectively. Statistical analysis showed that lactation was associated with low plasma inorganic phosphorus concentration. Both plasma calcium and inorganic phosphorus concentration declined with increasing age. In contrast, pregnancy was without effect.

12.15 (Potato Marketing Board), Rothamsted Experimental Station & (The National Institute of Agricultural Engineering) (1964) *Survey of maincrop potatoes*, 1963. Potato Marketing Board Report.

In a survey of 905 farms in Great Britain, information was obtained on current farming practices in growing, harvesting and storing maincrop potatoes. A similar survey was done in 1958. Yields were estimated from crop samples from one field on each farm, and on a sub-sample of these fields a further visit was made to determine the weight of tubers left on the fields after harvest.

In many respects changes in maincrop potato growing since 1958 were small. Among the more important changes were increases in fertiliser use by about 10% for N and 5% for P and K and, in some parts of England, a decrease in use of FYM. Rather more of the acreage was planted with chitted seed in 1963 than in 1958, and the weight of the seed planted increased by 10%, mainly because size of set increased. There was more machine planting, particularly by machines working on ridged land, but hand planting is still common, especially on farms with large acreages of potatoes where most of the seed is chitted.

Crops were sprayed more frequently for blight control, and there was more haulm destruction.

Much more use was made of harvesters and elevator diggers than in 1958, but the spinner is still the most common implement used. Apart from the introduction of complete harvesters, there has been little change in methods of handling the crop at lifting. Storage methods have not changed much, but rather more of the produce is now being stored in buildings.

12.16 (Smith, W. R.) & Boyd, D. A. (1964) Charolais trials in England and Wales: interim report on comparisons under intensive feeding systems. *Agriculture, Lond.* **71**, 398–404.

Preliminary results are reported of trials to compare the value of Charolais bulls with bulls of British breeds as sires of beef cattle in dairy herds.

Compared with the Hereford × Friesian cross the Charolais × Friesian had a somewhat greater liveweight gain per day, better food conversion and a higher killing-out percentage. Differences of carcase quality were small; the Hereford crosses had a rather greater fat cover and graded slightly better.

In comparison with pure Friesians, the Charolais × Friesian cross heifers made greater daily liveweight gains, but for the steers the difference was small. There is as yet insufficient information to compare the food conversion rates of these two crosses. Killing-out percentage, hindquarters as percentage of the whole carcase and most carcase scores favoured the Charolais crosses rather than the pure Friesians of both sexes. Comparisons of the Charolais crosses with those from other British beef breeds of bull were too few to be of any value individually; taken together, the average results did not differ substantially from those for the Charolais × Friesian and Hereford × Friesian crosses.

12.17 Vernon, A. J. & Morris, Marjory G. (1964) Variability in West African Peasant Cocoa Farms: Time studies on Agodi cocoa yields. *J. hort. Sci.* **39**. (In the press.)

From 18 years' yields of 2,500 cocoa trees in a group of small farms correlation coefficients $r(p, i, q)$ were calculated for the mean yields of single trees, $\frac{1}{30}$-acre

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plots and whole farms between an earlier period of p years and a later period of q years separated by an interval of i years.

Values of $r(1, i, 1)$ for single trees showed r for $i = 0$, 2 and 4 to lie below the curve fitted for odd values of i. This provides evidence of biennialism.

Values of r for plots and whole farms were calculated for every possible combination of $p = 1, 2$, $q = 1, 2, 4, 8$ and i taken to its maximum. The results indicate that one year's pre-recording reduces the error variance of the first experimental year on average by a factor of two. The reduction declines gradually for subsequent experimental years, but for mean yields over periods immediately following pre-recording the reduction is not affected by the length of the period. Gain in accuracy from two years' pre-recording is greater than from one, and may be well worth the extra cost if it does not delay the experiment.

12.18 YATES, F. (1964) Fiducial probability, recognisable sub-sets and Behrens' test. *Biometrics* **20**, 343–360.

Fisher's concept of fiducial probability has been extensively criticised by theoretical statisticians; in particular, Fisher's justification, based on the fiducial argument, of Behrens' test for the difference of the means of two samples from normal distributions with unknown variances, gave rise to doubt. The paper reviews the arguments put forward by Fisher and the objections raised against them, and also gives some examples of the absurdities to which the non-Fisherian approach has led.

12.19 YATES, F. & BOYD, D. A. (1964) Two decades of Surveys of Fertiliser Practice. *Outl. Agric.* (In the press.)

The paper describes the origin and development of the Surveys of Fertiliser Practice which have been conducted jointly by the National Agricultural Advisory Service, the Fertiliser Manufacturers' Association and Rothamsted since 1942, and assesses the value of the information obtained from them.

12.20 YATES, F. & HEALY, M. J. R. (1964) How should we reform the teaching of statistics? *Jl R. statist. Soc.* A **127**, 199–210.

This paper reviews the content of statistical courses at universities and technical colleges, as revealed by published syllabuses and examination papers, and in the light of interviewing candidates for statistical posts. It is suggested that in many of the courses there is undue emphasis on difficult mathematical theory, much of which is of doubtful relevance to the types of problem likely to be encountered in real life. In the opinion of the authors the basis of any general course in statistics should be the study of Gaussian least squares and normal error theory. Within this theory, experimental design is of the greatest importance, both for its own sake and for the insight which it provides into the underlying logic of statistical arguments.

Statistical teaching would be greatly improved if statistical departments undertook to provide an effective statistical service for their colleagues in the other sciences. Close contacts with other workers ensure that statisticians' attention is drawn to problems urgently needing solution, and this will be reflected in the contents of the courses they teach. As part of this service, statisticians will have to become more closely acquainted with electronic computers, and this, too, should be reflected in what they teach, and would enable present-day syllabuses to be lightened by the omission of material which is no longer relevant.

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Broom's Barn Experimental Station

Thesis

16.1 Scott, R. K. (1964) The relationship between leaf growth and yield of sugar beet. Ph.D. Thesis, University of Nottingham.

General Papers

16.2 Dunning, R. A. (1964) Sugar beet seed dressings; control of wireworms and aphids. *Eastern Daily Press*—Agricultural supplement, October.

16.3 Hull, R. (1964) Some causes of poor sugar beet crops. *Farming World*—Agricultural supplement, March.

16.4 Hull, R. (1964) The spray warning scheme to control virus yellows in sugar beet. *Eastern Daily Press*—Agricultural supplement, October.

Research Papers

16.5 Broadbent, L., Burt, P. E. & Heathcote, G. D. (1964) Home production of seed for early potatoes. 6. Insecticides applied to the soil or tubers. *Expl Hort.* **11**, 40–50.
(For summary see No. 9.6.)

16.6 Burt, P. E., Heathcote, G. D. & Broadbent, L. (1964) The use of insecticides to find when leaf roll and Y viruses spread within potato crops. *Ann. appl. Biol.* **54**, 13–22.
(For summary see No. 9.7.)

16.7 Dunning, R. A. & Winder, G. H. W. (1965) The effect of insecticide applications to the sugar beet crop early in the season on aphid and yellows incidence. *Pl. Path.* (In the press.)

A proportion of the sugar-beet crop is sprayed with insecticides to control such pests as pygmy mangold beetle, flea beetle and mangold fly. Systemic insecticides used for this purpose, although usually applied earlier than sprays for aphid and yellows control, usually decreased the incidence of yellows. Trichlorphon sometimes increased yellows incidence. Materials such as trichlorphon that do not kill aphids are not recommended for use against mangold fly when aphids are present unless used with a systemic aphicide.

16.8 Heathcote, G. D. & Cockbain, A. J. (1964) Transmission of beet yellows virus by alate and apterous aphids. *Ann. appl. Biol.* **53**, 259–266.

Myzus persicae alatae and apterae were consistently better vectors than *Aphis fabae* of beet yellows virus, but there was little difference between the ability of alatae and apterae of each species to transmit. Alatae born and reared on infected plants transmitted no more readily than alatae that had fed on infected plants for only 1 day; few were infective after feeding for 30–60 minutes. Alatae transmitted as readily after a 4-hour flight as after a 15-minute one. Most individuals ceased to be infective within 2 days of leaving infected plants, and most alatae ceased to fly 3–5 days after the final ecdysis, because their flight muscles autolysed.

A. fabae and *Rhopalosiphoninus staphyleae* transmitted BYV rather less than half as often as did *M. persicae*, and *Macrosiphum euphorbiae* and *Aulacorthum solani* transmitted only rarely.

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16.9 HEATHCOTE, G. D., DUNNING, R. A. & WOLFE, MARIE D. (1965) Aphids on sugar beet and some weeds in England, and notes on weeds as a source of beet viruses. *Pl. Path.* (In the press.)

Samples of aphids collected from beet early in the season contained alatae of many species but apterae of few species. *Macrosiphum solanifolii* occurred in nearly as many samples as *Myzus persicae*, but many more were alate. The proportion of green aphids to black decreased from May to July. The clamp aphid, *Rhopalosiphoninus staphyleae*, was not found in these samples.

On average, 36% of weed samples collected in early spring were infested, more with *Myzus ascalonicus* than with any other aphid. Aphids from the weeds infected few test plants with beet viruses. Although wild beet provides perennial sources of viruses, few aphids usually occur on them in spring and they are probably only locally important.

16.10 TINKER, P. B. (1964) Studies on soil potassium. III. Cation activity ratios in acid Nigerian soils. *J. Soil Sci.* **15**, 24–34.

The method of determining the activity ratio $\frac{(K^+)}{\sqrt{(Ca^{++} + Mg^{++})}}$ (AR) described by Beckett in Part II of this series of papers was applied to a range of acid Nigerian soils. With the very acid soils, it was necessary to add aluminium ions to the solution to obtain equilibrium. A method for obtaining the true equilibrium solution composition for K, (Ca + Mg) and Al is described, and some typical results given. It was necessary to add benzene to prevent biological activity during sedimentation at 33° C. Altering the total concentration of the solution did not affect the activity ratio. A minority of soils showed evidence of transfer of potassium to non-exchangeable forms during equilibrium. The slopes of the (exchangeable K)–AR curves in a single soil depended on the amounts of soil Ca + Mg present. In comparisons between several soils exchange capacity also had an effect. The Gapon equation was approximately correct for these soils over limited ranges.

16.11 TINKER, P. B. (1964) Studies on soil potassium. IV. Equilibrium cation activity ratios and responses to potassium fertilizer of Nigerian oil palms. *J. Soil Sci.* **15**, 35–41.

The composition of the topsoil in Nigerian oil-palm plantations is expected to be closely related to the potassium status of the palms. K–(Ca + Mg) activity ratios obtained from measurements of the equilibrium solutions were not related to yield response when potassium was applied to very acid soils. This lack of relationship was further indicated by the failure of liming to affect potassium response, though the equilibrium activity ratios of acid soils were strongly affected.

Yield response was related to the K–(Ca + Mg) activity ratios of the soils determined in presence of enough lime-water to remove soluble aluminium.

A better relationship was obtained between yield response and a "unified activity ratio" $\frac{(K^+)}{\sqrt{(Ca^{++} + Mg^{++}) + P^3\sqrt{(Al^{+++})}}}$, called AR_u, the activities being those found in the true equilibrium solutions. AR_u depended less than the K–(Ca + Mg) activity ratio on exchangeable Ca + Mg.

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Soil Survey of England and Wales

Books

17.1 AVERY, B. W. (1964) *The soils and land use of the district around Aylesbury and Hemel Hempstead.* London: H.M. Stationery Office, vii, 216 pp.

17.2 CLAYDEN, B. (1964) *Soils of the Middle Teign Valley district of Devon.* Harpenden: Rothamsted Experimental Station, vii, 111 pp.

17.3 MACKNEY, D. & BURNHAM, C. P. (1964) *The soils of the West Midlands.* Harpenden: Rothamsted Experimental Station, viii, 111 pp.

Thesis

17.4 BULLOCK, P. (1964) A study of the origin and development of soils over Carboniferous Limestone in the Malham district of Yorkshire. M.Sc. Thesis, University of Leeds.

General Papers

17.5 *Soil map on 3rd Edition Sheet 166* (*Church Stretton*) (1964) Southampton: Ordnance Survey.

17.6 AVERY, B. W. (1964) Problems of soil classification with particular reference to the proposed 1 : 1,000,000 soil map of Europe. *F.A.O. Working Party on Soil Classification, Survey and Soil Resources, 1st Session. Florence.*

17.7 (BUNTING, B. T.) & GREEN, R .D. (1964) The soils and geomorphology of an area around Dorking. *20th int. Geogr. Congr. Guide to London Excursions*, pp. 71–78.

17.8 (CHARLES, A. H.) & CRAMPTON, C. B. (1963) Selection processes operating on grass populations. *Rep. Welsh Soils Discussion Group* No. 4.

17.9 (CHARLES, A. H.) & RUDEFORTH, C. C. (1964) Intensive observations on soil related to productivity. *Rep. Welsh Soils Discussion Group* No. 5.

17.10 CLAYDEN, B. & MANLEY, D. J. R. (1964) The soils of the Dartmoor granite. In: *Dartmoor Essays*, ed. I. G. Simmons, Devon Assn. Adv. Sci. Lit and Art, pp. 117–140.

17.11 CRAMPTON, C. B. (1964) Historic and present land use on the S. Wales Coalfield. A comparative study of forest and pasture. *Rep. Welsh Soils Discussion Group* No. 5.

17.12 FINDLAY, D. C. (1964) Soils. In: *A survey and policy concerning the archaeology of the Bristol region. Pt. I. To the Norman Conquest.* Bristol Archaeological Research Group, pp. 11–18.

17.13 RUDEFORTH, C. C. (1963) Leaching and the podzolisation process. *Rep. Welsh Soils Discussion Group* No. 4.

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Research Papers

17.14 Bascomb, C. L. (1964) A rapid method for the determination of cation-exchange capacity of calcareous and non-calcareous soils. *J. Sci. Fd Agri.* **15**, 821–823.

An EDTA titration is used to measure the amount of magnesium exchanged from a standard solution by a Ba-soil, and enables the cation-exchange capacity to be calculated. Advantages of the method are its speed and that the sample does not have to be washed exhaustively, so avoiding possible hydrolysis. It compares favourably with standard A.O.A.C. procedure and is more widely applicable; soils rich in organic matter, e.g., peats, or with much calcium carbonate can be handled without difficulty.

17.15 (Boaler, S. B.) & Hodge, C. A. H. (1964) Observations on vegetation arcs in Northern Region, Somali Republic. *J. Ecol.* **52**, 511–544.

Vegetation arcs are strips of vegetation oriented along the contour and separated by bare or almost bare ground. They usually consist of a front zone dominated by stoloniferous clump grasses, mainly *Sponobolus* spp. and a body zone where either *Chrysopogon aucheri* or *Andropogon killeri* is dominant. Trees are generally absent, but a subsidiary arc of mature trees may occur downhill from the grass arc.

Arcs occur on slopes of about 1 in 100 to 1 in 450 where the dry season is pronounced and the annual rainfall is 5–12 in.; they are from 50 to 250 ft wide and up to 1 mile long. Rain collects at the upslope edge, and much more water enters the soil under arcs than on bare ground.

The pattern of distribution, which appears to be stable, produces optimum moisture conditions for the roots. Arcs are probably formed by a former complete ground cover degrading because of climatic deterioration or overgrazing. The death of plants leaves gaps in the cover, but the plants at the downslope edge are strengthened by receiving run-off. With further deterioration the gaps elongate and coalesce along the contour, the strengthened plants at the downslope edge remaining as arcs.

Chrysopogon arcs occurred on deep clay soils with a loose, granular-structured surface. Potholes, 12 in. deep and several inches wide, in the arcs are associated with vertical cracks in the soil, and probably form by collapse of the topsoil into the subsoil following shrinkage of the clay during the dry season. Potholes are not formed between arcs probably because the soil there is rarely wetted.

17.16 Burnham, C. P. (1964) The occurrence of eluviated clay in soils of Central England. *VIII International Congress of Soil Science VII*, 46–47.

Micromorphological studies of a wide range of uncultivated soils in Central England show that most subsurface layers contain oriented clay that has probably been eluviated. Some of the layers are argillic Bt horizons, but in others the oriented clay is a minor feature. The form and position of the clay in the profile are discussed together with the environmental factors which apparently influence its occurrence.

17.17 Burnham, C. P. & Mackney, D. (1964) Soils of Shropshire. *Field Studies*. II, 83–113.

Relationships between semi-natural vegetation and the soils are emphasised and the agricultural and ecological characters of the soil associations are summarised. A soil classification is presented, and the pedological and ecological characters of each soil association are discussed.

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A coloured soil map at $\frac{1}{4}$ in. to 1 mile shows eleven associations briefly described in the legend.

17.18 CRAMPTON, C. B. (1964) Preliminary studies of the historic succession of plants and soils on selected archaeological sites in South Wales. *Bull. Bd. Celtic Studies* **20**, 440–449.

Pollen spectra in soil profiles at selected archaeological sites were correlated. There may have been a heathland phase during Neolithic times, but forest was established by Middle Bronze Age times. In a dry and warm environment oak was dominant and associated with *sols bruns acides*. Later and during the Iron Age, *Polypodium* became extensive and was possibly associated with the formation of podzols. Heathland probably developed during post-Roman times, the dominance of Ericaceae being contemporaneous with an extension of blanket peat. Elsewhere, "podzols with gleying" and peaty gleyed podzols were probably forming. Grassland extended during late medieval times and has continued.

17.19 CRAMPTON, C. B. (1964) Certain aspects of soils developed on calcareous parent materials in South Wales. *Trans. Cardiff Nat. Soc.* **91**.

Deep soils over calcareous substrata show pronounced horizonation and a zone enriched with clay immediately above the calcareous layer. Mostly such soils are freely drained, but such a zone can occur in impeded soils, sometimes below peat, when the underlying drift contains many limestone boulders. Oriented clay lining grains and pores are more characteristic of deeper than shallow profiles, particularly in the clay-enriched zone, where they bind the slightly weathered mineral grains. The clay mineral composition is unchanged both above and in the zone, and enrichment is probably due to downward translocation of clay. In some profiles organic matter has also moved downwards to accumulate here, producing the characteristic dark colours seen in the field. The high pH-value has probably encouraged preferential precipitation.

17.20 HODGSON, J. M. (1964) The low-level Pleistocene marine sands and gravels of the West Sussex Coastal Plain. *Proc. Geol. Ass.* **75**, 547–561.

The distribution, nature, origin and relationships of these deposits are described and discussed. Much of the underlying wave-cut platform has dissolved where it cuts across the Chalk. This solution, which post-dates the beach, gives a variation in platform height independent of its original slope. The platform rises from about 6 ft O.D. to at least $18\frac{1}{2}$ ft O.D., and probably several feet higher, and the deposits, widespread and continuous except over the Chalk, rise to an observed maximum of 47 ft O.D. There is no evidence for the separate existence of more than one deposit within these limits. The beach is regarded as a westward continuation of the similar beach at Black Rock, Brighton.

17.21 MACKNEY, D. & BURNHAM, C. P. (1964) A preliminary study of some slope soils in Wales and the Welsh Borderland. *J. Soil Sci.* **15**, 319–330.

Two acid well-drained soils with A(B)C profiles are correlated with *sols bruns acides*; they probably contain different amounts of soluble Fe_2O_3 because weathering is more intense in districts of greater rainfall. The humus-iron podzol described is finer in texture and micromorphologically different from typical profiles of its class. A fourth soil is regarded as transitional between these two classes because it has a prominent brown B horizon of redder hue than the overlying unbleached A horizon; organic carbon values are greater than those of *sols bruns acides*, but there is no horizon of accumulation; SiO_2/R_2O_3 ratios are typical of podzols though differences are smaller; the micromorphology of the B horizon is similar to that of the B_s horizon of the humus-iron podzol.

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17.22 (PERRIN, R. S. M., WILLIS, E. H.) & HODGE, C. A. H. (1964) Dating humus podzols by residual radiocarbon activity. *Nature, Lond.* **202,** 165–166.

The apparent ages of the humus B horizons of Breckland podzols were determined by measurement of the residual activity of contained carbon-14 and ranged between 1,580 and 2,860 years B.P. These represent the minimum ages of the podzols, and their significance is discussed.

17.23 PRITCHARD, D. T. (1964) Determination of aluminium in silicates with DCTA. *Analytica chim. Acta*, **32**, 184–186.

1,2-diaminocyclohexane-tetra-acetic acid (DCTA) reacts quantitatively with aluminium in the cold and in concentrated solutions of neutral salts (e.g., 1*M*-NaCl). Its application to the determination of aluminium is described. Its presence enhances the separation of aluminium from iron, titanium, magnesium, calcium and manganese when using excess sodium hydroxide.

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