ROTHAMSTED RESEARCH

Report for 1962

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Abstracts of Papers

Rothamsted Research

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ABSTRACTS OF PAPERS

Physics Department

Thesis

1.1 Rose, D. A. (1962). The physics of water movement in porous materials. Ph.D. Thesis, University of London.

General Papers

1.2 Penman, H. L. (1963). Vegetation and hydrology. *Tech. Commun. Bur. Soil Sci., Harpenden*, No. 53, 124 pp.

1.3 Penman, H. L. (1963). Supplementary irrigation. For United Nations Conference, Geneva.

Research Papers

1.4 Cashen, G. H. (1963). Electric charges and thixotropy of clays. *Nature, Lond.* **197**, 349–350.

In the time required to remove electrolyte from an acid washed clay the clay becomes an aluminium clay with the permanent charge balanced by Al^{3+} ions in a Stern layer. When five-sixths of this charge is neutralised by alkali there are changes in the behaviour of the clay, some subtle, some gross. The hypothesis is advanced that at this stage the Al_3^+ ions have come together to produce complex ions of the type $[Al_6(OH)_{15}]^{3+}$ and that these, under their mutual repulsions, settle near the surface as far apart as possible, i.e., the clay particles are positively charged near the periphery by an excess of complex ions in the Stern layer. The concept explains the new evidence that inspired it, explains some puzzles in the rheology of clays, and provides an alternative explanation of others.

1.5 Monteith, J. L. (1962). Attenuation of solar radiation: a climatological study. *Quart. J. R. met. Soc.* **88**, 508–521.

Daily totals of direct and diffuse radiation transmitted by a cloudless atmosphere are calculated from the absorption and scattering coefficients given by Houghton (1954). Estimates of total (direct plus diffuse) radiation (T_1) agree well with extreme maxima recorded at several British stations, but during spells of cloudless summer weather in south-east England attenuation by aerosol decreases total radiation on average by 10%, and increases the ratio of diffuse to total radiation by about 8% of T_1. The ratio of mean monthly radiation at country stations T_2 to estimated T_1 can be expressed as a function of cloud reflection (p), cloud absorption (ϕ) and surface reflection (x); and the values $p = 0{\cdot}50, \phi = 0{\cdot}16$ are consistent with surface and aerial measurements. With $x = 0{\cdot}20$, T_2/T_1 is approximately $(1–0{\cdot}61\ c)$ $(0{\cdot}6 < c < 0{\cdot}9)$, where c is fractional cloudiness. The diffuse component beneath cloud can be estimated separately. Absorption by man-made aerosol reaches maxima of 26% at Kew and 30% at Kingsway in January, and varies seasonally with measured smoke. In the country absorption by pollution is negligible in summer, but may reach 5–10% in winter. At Kew absorption by cloud and total back-scattering (local planetary albedo) are about 9 and 41% of extra-terrestrial flux respectively, with little seasonal variation.

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1.6 MONTEITH, J. L. (1962). Measurement and interpretation of carbon dioxide fluxes in the field. *Neth. J. agric. Sci.* **10**, 334–346.

The dry-matter production of field crops can be estimated from their net uptake of carbon dioxide, and vertical profiles of CO_2 concentration show that crop plants normally assimilate CO_2 both from the atmosphere and from the soil. The atmospheric component can be estimated from the CO_2 concentration at two heights and the wind speed at three heights above the crop; and the soil component by direct absorption in soda lime. Measurements over grass and beans at Rothamsted gave a soil CO_2 production of about 0·03 mg cm^{-2} hr^{-1} and maximum gross rates of photosynthesis about 0·2 mg CO_2 cm^{-2} hr^{-1}. In terms of total solar radiation (0·3–2 μ), the efficiency of photosynthesis varied from about 1% in bright sunshine to 2% or more with cloud, agreeing well with measurements by Gaastra on selected plants in the laboratory. An attempt to establish the complete CO_2 balance for beans emphasised the importance of respiratory flux in determining dry-matter production. Conventionally assumed respiration rates are inadequate and field measurements are urgently needed.

1.7 MONTEITH, J. L. (1963). Gas exchange in plant communities. In: *Environmental Control of Plant Growth.* New York: Academic Press.

Given the concentration of water vapour and CO_2 in the free atmosphere, the transpiration and assimilation rates of a plant community can be estimated from the diffusive resistances of the system. Water-vapour transfer is governed by the aerodynamic resistance of the plant canopy (depending on wind speed, surface roughness and atmospheric stability) and by the resistance of leaves (depending on stomatal size and population). The CO_2 circuit is complicated by respiration and by additional resistances in the mesophyll and chloroplast. In two examples, resistances for a field of beans are calculated from measured fluxes and gradients. Stomatal resistance is several times greater than the aerodynamic resistance, but is less than the light-dependent chloroplast resistance when soil moisture is adequate throughout the day. Both the stomatal and chloroplast resistances increase with decreasing soil moisture.

1.8 MONTEITH, J. L. & SZEICZ, G. (1962). Radiative temperature in the heat balance of natural surfaces. *Quart. J. R. met. Soc.* **88**, 496–507.

A Linke–Feussner radiometer was used to measure the radiative temperature of natural surfaces, with small errors caused by the divergence of radiative flux and by its angular variation. On typical cloudless summer days the maximum temperature of tall crops and of open water was close to maximum air temperature; a bare soil surface exceeded air temperature by 20°; short grass was the coldest surface at night. A linear variation of net (total) radiation with net shortwave radiation was established for several tall crops, and the increase in longwave loss per unit increase of net radiation (heating coefficient) was 0·08. Daily totals of net radiation as a percentage of solar radiation income were: 37% (bare soil), 41% (short grass), 46% (tall crop) and 53% (water).

When the aerodynamic character of a crop is known the effective resistance of the stomata to water-vapour diffusion can be related theoretically to the difference between surface and air temperature. For rough vegetation, estimated stomatal resistance is 0·4–0·8 sec cm^{-1} and the estimated heating coefficient is almost independent of wind speed at about 0·1.

1.9 PENMAN, H. L. (1962). Weather and crops. *Quart. J. R. met. Soc.* **88**, 209–219.

Crop-weather interactions occur in many forms, the most fundamental presenting the greatest challenge: field crops rarely "fix" more than 1% of solar radia-

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tion, and reasoning suggests that 8 or 10% might be attained. When water supply is eliminated as a variable (by irrigation) growth rates of some crops are proportional to potential transpiration rates. The effect of rain as a weather element is best considered in terms of the soil-moisture deficit experienced by the crop: for the same crops there are limiting values of the deficit below which growth suffers very little check, and above which growth is effectively zero. Grass, potatoes, beans and sugar beet fit into this pattern; cereals do not.

The meteorology of CO_2 transfers between air and crop and ground shows promise in meeting the fundamental challenge.

Chemistry Department

Theses

2.1 Gasser, J. K. R. (1962). Investigations on the use of urea as a fertiliser. Ph.D. Thesis, University of London.

2.2 Salmon, R. C. (1962). Magnesium relationships in some British soils. Ph.D. Thesis, University of London.

2.3 Vaidyanathan, L. V. (1961). A study of the inorganic soil phosphate by the use of mixed cation-anion exchange resin systems and its relation to the isotopically exchangeable phosphate in the soil. Ph.D. Thesis, University of London.

General Papers

2.4 Arnold, P. W. (1962). Soil potassium and its availability to plants. *Outlook on Agriculture* **3**, 263.

2.5 Cooke, G. W. (1961). Placement and timing of fertiliser applications. *Fertil. Feed. St. J.* **55**, 570–578.

2.6 Cooke, G. W. (1962). Saving by soil testing. *Farming Express* 8 February.

2.7 Cooke, G. W. (1962). Fruits of research in fertiliser use. *Span* **5**, 88–91.

2.8 Cooke, G. W. (1962). Nitrogen, the key to grass production. *Dairy Fmr* **9** (3), 51–53.

2.9 Cooke, G. W. (1962). Timing and placement of fertilisers. *World Crops* **14**, 108–112.

2.10 Cooke, G. W. (1962). Liquid fertilisers. *J. Inst. Corn Merch.* **10** (4), 19–21.

2.11 Cooke, G. W. (1962). Chemical aspects of soil fertility. *Soils & Fert.* **25**, 417–420.

2.12 Cooke, G. W. (1962). Soils and fertilisers. *J. R. agric. Soc.* **123**, 134–156.

2.13 Cooke, G. W. (1962). Assessing the capabilities of soils for producing crops. International Soil Congress, New Zealand. *Transactions of Comm. IV and Comm. V., C 17.*

2.14 Mattingly, G. E. G. (1961). Some recent developments in soil chemistry in relation to crop growth. *Agric. Vet. Chemic.* **2**, 223–225.

2.15 Mattingly, G. E. G. (1961). Crops. *Rep. Progr. appl. Chem.* **46**, 395–402.

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2.16 NOWAKOWSKI, T. Z. (1962). The availability of nitrogen in organic manures, investigations done in Great Britain during 1945–56. *Proceedings of Symposium on Organic Manures, Szczecin, Poland, 6–11 October, 1959.*

2.17 WIDDOWSON, F. V. (1962). Applying fertilisers for spring barley. *Ann. appl. Biol.* **50**, 356–360.

RESEARCH PAPERS

2.18 ARNOLD, P. W. (1962). The potassium status of some English soils considered as a problem of energy relationships. *Proc. Fertil. Soc.* No. 72, 25–43.

Sixty-four soils from 50 sites in England were cropped with perennial ryegrass in the greenhouse for 36 days. Soils which supplied small and large amounts of potassium to the grass were well separated on the basis of their exchangeable K contents, but the coefficient (r) of correlation between uptake and exchangeable K for 36 of the soils, which contained 10–20 mg exchangeable K/100 g soil, was only 0·35. The K status of the soils was further defined by the difference in free energy ($G_{Ca,K}$) between potassium and divalent cations. There was a near-linear relationship between potassium uptakes by the grass and values for $G_{Ca,K}$ for 54 of the 64 soils. The parameter $G_{Ca,K}$ was, however, inadequate for defining the K-supplying power of all the soils examined.

2.19 BARROW, N. J. & JENKINSON, D. S. (1962). The effect of water-logging on fixation of nitrogen by soil incubated with straw. *Plant & Soil* **16**, 258–262.

When straw was incubated with a calcareous soil under water-logged conditions nitrogen fixation occurred if the gas above the incubation contained oxygen: no detectable fixation occurred if oxygen was excluded. Moist soil failed to fix nitrogen when incubated with straw in either the presence of absence of oxygen.

2.20 BUNTING, A. H. (1963). Experiments on organic manures, 1942–49. *J. agric. Sci.* **60**, 121–140.

One hundred and thirteen experiments were done on 56 sites, during 8 years, to investigate the composition and agricultural effects of farmyard manure (FYM), sewage sludge and composts of straw with sludge or with inorganic N. The manures had on average from 1·9 to 2·6% N in dry matter; P_2O_5 contents were more varied, from 1·1% in straw composts to 1·6% in FYM and over 2% in sewage sludges. FYM was outstanding in providing 2% K_2O in dry matter, the other materials had only 0·3–0·6% K_2O. Rates tested were 8 and 16 tons/acre of strawy manures and 5 and 10 tons of sludge dry matter/acre for farm crops; double these rates were used for horticultural crops. Fertilisers were also tested, but generally at rates well below the (economic) optima.

FYM supplied K to crops, as did other strawy manures. Inorganic N composts did not supply P, but all the other materials did, and all supplied N. The sewage sludges differed greatly from strawy materials in not supplying K to crops; they are primarily sources of N and P; the K they contain (0·3–0·4% in dry matter) is presumably insoluble and unavailable.

The gross effects of the materials on crop yields were associated with their ability to supply nutrients. FYM was best. Responses from sludge–straw composts were about half those from FYM except at high rates and for cabbage, where the composts did better. Composts of straw with inorganic N had much smaller effects on yield than sludge–straw composts; ploughing in straw with inorganic N, or with sewage sludge, had much the same effect as inorganic-N composts.

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The sub-optimal fertiliser dressings used greatly lessened the effects of all organic materials except with red beet, which responded particularly well to FYM and to straw–sludge composts. As the fertiliser rates were low, it was difficult to separate "complex" effects that could not simply be ascribed to increases in plant nutrient supplies. Only 10 out of the 113 experiments showed that organic manures had complex effects on crop yields that were not easily explained in terms of extra nutrient supplies; all the sites were on light soils. There seemed no special need for organic manuring on heavy soils or on shallow soils over limestone. All the materials producing apparently complex effects involved rotting straw. There was no evidence that organic matter as such was important; sewage sludge supplied much more organic matter/acre than FYM, but was much less effective.

For farm and horticultural crops sewage sludge is only useful as a source of N and P; when it is used K must be supplied separately. Some sludges contain heavy metals from industrial wastes, and these can be harmful to crops. Well-rotted sludge–straw composts at 30 tons/acre can approach similar quantities of FYM in their effects on crop yield. Composts of straw with inorganic N do not appear useful. The direct ploughing in of straw had little merit on the soils used for these experiments.

2.21 CHAKRAVARTI, S. N. & TALIBUDEEN, O. (1962). Phosphate equilibria in acid soils. *J. Soil Sci.* **13**, 231–240.

Phosphate equilibria in 54 acid soils are examined and referred to equilibria with variscite and strengite. The equilibrium phosphate concentration in British soils is governed by phosphate residues less basic than of these compounds and is approximately similar to that obtained by treatment of montmorillonite with 10^{-5} *M* phosphate solutions for 9 months. In Indian soils both compounds are effective in controlling phosphate concentrations over the pH range 3·8–5·7.

Kaolinite and glauconite treated with 10^{-5} *M* phosphate for 9 months exhibit characteristics intermediate between the two groups of soils.

2.22 CUNNINGHAM, R. K. (1962). Cation-anion relationships in Italian ryegrass (*Lolium multiflorum*). *Nature, Lond.* **196**, 1230–31.

Total cation : total anion ratios in Italian ryegrass depended on the total N in the grass, and on the form of nitrogen taken up.

2.23 CUNNINGHAM, R. K. (1962). Determination of total sulphur in plant material. *Chem. & Ind.* 2120–2121.

An indirect flame photometric method for determining total sulphur in plant material was described.

2.24 CUNNINGHAM, R. K. (1962). Mineral nitrogen in tropical forest soils. *J. agric. Sci.* **59**, 257–262.

$\triangle$ min-N_{ad} is the most satisfactory measurement for assessing mineralisable-N in the tropical forest soils used; values are treble those for $\triangle$ min-N_f and then increase even further on storage. Comparisons of $\triangle$ min-N_{ad} are pointless unless methods of sampling, drying, storing and incubating are standardised.

$\triangle$ min-N_{ad} is correlated with total N and organic C but not pH.

Undisturbed tropical forest soils can produce very large quantities of mineral N, particularly in their surface layers; this probably accounts for small responses of plants to added N. These soils can be extensively cultivated only when organic matter is preserved by protecting cleared soil.

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Added nitrogen was leached more rapidly from these soils than from comparable temperate soils, but not fast enough to prevent absorption by plants.

2.25 CUNNINGHAM, R. K. & ARNOLD, P. W. (1962). The shade and fertiliser requirements of cacao (*Theobroma cacao*) in Ghana. *J. Sci. Fd Agric.* **13**, 213–221.

Experiments to examine the shade and nutrient requirements of cacao are described, and preliminary results are presented. A significant response to phosphate was obtained under shade when pests, diseases and weeds were controlled. Removing shade results in highly significant increases in yield, with a positive interaction between increased light and applied nutrients. Fertilised, unshaded cacao yielded double as much as previously considered to be the maximum for Amelonado cacao. The application of these results to farmers' shaded cacao and to a more intensive system of growing the crop without shade are discussed. Attention is drawn to the dangers of removing shade and to the importance of associated factors, such as pest distribution, incidence of weeds, adverse dry season effects and soil degradation.

2.26 GASSER, J. K. R. (1962). Transformation, leaching and uptake of fertiliser-N applied to winter and to spring wheat grown on a light soil. *J. Sci. Fd Agric.* **13**, 367–375.

Winter and spring wheat were grown on a light soil without fertiliser-N or with 100 lb of N/acre applied as ammonium sulphate or "calcium nitrate"; dressings were applied in autumn or in spring. The same treatments were also applied to uncropped soil. Most of the nitrate-N in unfertilised soil and that from "calcium nitrate" applied in the autumn had been leached below 36 in. by the following March. Ammonium sulphate nitrified slowly on one plot where the soil was acid, and the dressing applied in autumn was partly retained as ammonium-N; but on other plots most of the nitrogen was nitrified and had been leached below 36 in. by the following March. With no crops, the mineral-N content of unfertilised plots and of those receiving fertiliser-N in the autumn, increased from March to August. Fertiliser-N applied in the spring remained in the surface layers and would have been available to a crop throughout the growing season. Wheat removed both soil mineral-N and fertiliser-N from March onwards; by the end of May most of the fertiliser-N applied in spring had been taken up from the soil by the crop. At harvest the soil of all plots under wheat contained similar, but small amounts of mineral-N. Both unfertilised wheat and wheat receiving fertiliser-N in autumn had maximum dry matter and N content at harvest. Dry matter produced by wheat with fertiliser-N in spring also increased to harvest, but most fertiliser-N was recovered in the crop in late May. Winter wheat had a similar total-N content at harvest as in late May, but spring wheat contained less at harvest. For both spring- and autumn-sown wheats the apparent recovery of fertiliser-N decreased between May and harvest.

2.27 MATTINGLY, G. E. G. & WILLIAMS, R. J. B. (1962). A note on the chemical analysis of a soil buried since Roman times. *J. Soil Sci.* **13**, 254–258.

The chemical composition of a soil buried beneath a Roman amphitheatre was compared with soil from the surrounding field and with the materials from which the amphitheatre was constructed. The calcium carbonate and total potassium contents of the buried soil and the cultivated surface soil were similar. The buried soil contained 0·78% carbon, 0·126% nitrogen and 0·044% organic phosphorus, and the surface soil 2·42% carbon, 0·318% nitrogen and 0·097% organic phosphorus. Much more phosphorus, soluble in 0·5*M*-sodium bicarbonate, was present in the buried soil (12·8 mg P/100 g) than in the surface

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soil (1·3 mg P/100 g). Losses of nitrogen since the soil was buried in Roman times were estimated to be about 70%.

2.28 NOWAKOWSKI, T. Z. (1962). Effects of nitrogen fertilisers on total nitrogen, soluble nitrogen and soluble carbohydrate contents of grass. *J. agric. Sci.* **59**, 387–392.

Italian ryegrass given ammonium sulphate or sodium nitrate at 56 or 112 lb N/acre was analysed for total nitrogen, soluble nitrogen (non-protein-nitrogen) and soluble carbohydrates. Ten days after applying fertiliser the differences in total-N between the grass receiving 56 and grass receiving 112 lb N/acre were very small. Total-N in grass decreased with growth, but the effect of the rate of nitrogen on total-N increased. At first the grass given sodium nitrate contained more soluble nitrogen than grass given ammonium sulphate, the difference being greater at 56 lb N/acre; soluble nitrogen decreased with increasing growth. Ten days after applying fertiliser the nitrate-N content of grass was very high (ranging from 0·1 to 0·9% in the D.M.) and it gradually decreased. At both levels of nitrogen application grass given sodium nitrate contained much more nitrate-N than grass given ammonium sulphate. Forty days after applying nitrogen the nitrate-N contents of grass which received 56 and 112 lb N/acre as ammonium sulphate were 0·039 and 0·222% of the dry matter, respectively; the grass supplied with sodium nitrate gave values of 0·082 and 0·438%. Total soluble carbohydrates in the grass were small early in growth and gradually increased. Nitrogen dressings had little effect on the content of soluble sugars (glucose + fructose + sucrose), but greatly decreased the fructosan. The pattern of changes in the total soluble carbohydrate content followed that in fructosan content. Early in growth, the total soluble carbohydrate/crude protein ratio was very small in grass from all treatments except the "control". This ratio increased with growth, and at the last sampling was 2·13 in grass receiving no nitrogen, and in grass supplied with 56 and 112 lb N/acre as ammonium sulphate it was 1·44 and 0·72 respectively; the corresponding figures for grass receiving sodium nitrate were 1·13 and 0·66. The total soluble carbohydrate carbon/soluble nitrogen ratio in grass with no nitrogen was 18 at the first sampling, and it increased gradually, reaching 70 at the last sampling. This ratio was considerably less with all nitrogen treatments than with "control". The values obtained with 112 lb N/acre were less than those obtained with 56 lb/acre, irrespective of the form of nitrogen used. The relationship between the soluble carbohydrate carbon content and the soluble nitrogen in grass is illustrated graphically and discussed.

2.29 VAIDYANATHAN, L. V. & TALIBUDEEN, O. (1962). Alteration in the surface properties of soils by ion exchange resins. *Nature, Lond.* **194**, 897.

Phosphate ions diffuse more slowly out of the soil in resin : soil suspensions than in suspensions of soil alone because multilayers of poly-electrolyte anions, formed by the chemical and abrasive decomposition of resins, are adsorbed on the soil surface. Caution is thus needed in interpreting results from experiments in which resins are used to extract nutrients from soil or to supply nutrients to plants, especially when considering rates of reaction and rates of uptake.

2.30 WARREN, R. G. & COOKE, G. W. (1962). Comparisons between methods of measuring soluble phosphorus and potassium in soils used for fertiliser experiments on sugar beet. *J. agric. Sci.* **59**, 269–274.

Eleven years of field experiments on manuring sugar beet were used by the late E. M. Crowther to compare methods of analysing soils for soluble P and K; this paper reports his work. The experiments were divided by soil analyses into groups of equal numbers of sites; average crop responses were used to value the

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analytical methods. Such tables of average results overvalue soil analyses, because each method was misleading in a small proportion of the fields used. A quantitative way was developed of assessing the gains from using soil analysis in planning fertilising and of comparing analytical methods. The total profit from uniformly manuring all the soils examined was compared with the profit made by using analyses to select a proportion only of the soils to be manured; the total amount of fertiliser used was the same with each way of planning manuring. The most efficient analytical method gave the most profit. For phosphate, differential manuring of sites selected by soil analysis was more profitable than uniform manuring with all the methods of measuring soluble P that were tested. The best method used a rapid extraction with dilute hydrochloric acid, but extracting with water (calcium bicarbonate solution was used for calcareous soils), or with citric acid solution, was nearly as effective. These three methods, using little solvent relative to soil, were more useful than methods using larger volumes of dilute sulphuric acid, dilute acetic acid and a lactate solution. The sugar beet responded more often to K than to P manuring, so there was less chance of making extra profit by using analyses to detect the richer soils where either no K fertiliser or small dressings only should have been given. Using the citric acid method of measuring soluble-K to separate the soils into groups of differential manuring was more profitable than giving uniform dressings to all fields; acetic acid was less effective than citric acid, and the hydrochloric acid method gave no advantage over uniform manuring with the heavier rate of potassium. Water-soluble K measurements were worse than acid-soluble values; using them to predict responses and manuring would have given less profit than uniform manuring at the heavier rate used.

2.31 WARREN, R. G. & JOHNSTON, A. E. (1962). The accumulation and loss of soil potassium in long-term experiments, Rothamsted and Woburn. *Proc. Fertil. Soc.* No. 72, 5–24.

The net withdrawal of potassium from soil depends on season, amount of K applied, type of crop and how it is used. The K balance between additions and withdrawals for a rotation can be determined accurately only from analyses of crops and manures for more than one cycle. In ley–arable experiments at Rothamsted more K was removed by cut grass and lucerne leys than was applied as fertiliser, the readily soluble K in the soil decreased and the yields of potatoes were less than after grazed ley. At Woburn readily soluble K in soil was increased by a 3-year grazed ley and by a single dressing of farmyard manure. Dressings of fertiliser K to the cut grass and lucerne plots of the Rothamsted experiments, equal to the K removed by the crops, corrected K deficiencies in the soils. The intensities of K-deficiency symptoms in barley following a deep cultivation experiment, and the % K in the plants, were related to soil analysis results for readily soluble K. Soil analysis appears to be a satisfactory and simple alternative to analysing crops and manures when determining the K balance of a rotation.

In the soils of the Barnfield Mangold Experiment there were large gains in ammonium acetate-soluble K from farmyard manure and from K fertiliser applied annually for about a hundred years. The gain in ammonium acetate-soluble K for uncropped soil from the K fertiliser dressings was estimated to be only one-seventh of the total amount of K added.

In laboratory experiments Rothamsted and Woburn soils fixed less K when kept wet than when alternately wetted and dried. Acid soils fixed much less K than neutral or slightly calcareous ones.

The value to crops of K residues in soil was measured in microplot experiments on the Exhaustion Land site at Rothamsted. Swedes, sugar beet and kale extracted more K from residues in the soil than from new additions of K

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fertiliser. For swedes, sugar beet and kale, the K fertiliser was applied broadcast and worked in; for potatoes it was applied between the ridges before planting. Potato yields were most from the K residues, which were estimated to be equal to 0·5 cwt of fresh fertiliser K/acre.

2.32 WIDDOWSON, F. V. & PENNY, A. (1962). Experiments with nitrogen and potash on potatoes. *Exp. Husbandry* No. 8, 30–39.

Seven experiments on main-crop potatoes in 1958 and six in 1959 compared responses to 0·5, 1·0 and 1·5 cwt N/acre (as ammonium sulphate) applied with 0·8, 1·6 or 2·4 cwt K_2O/acre (in 1958) and with 0·0, 1·2 or 2·4 cwt K_2O/acre (in 1959). The 1959 experiments also compared muriate and sulphate of potash. Responses to N differed greatly from centre to centre, but on average 1·0 cwt N/acre gave full yields each year. More than 0·8 cwt K_2O/acre decreased yields in 1958; in 1959 1·2 cwt K_2O/acre gave maximum yields. In 1959 muriate was slightly better than sulphate of potash in four out of six experiments. The mean response to N was not limited by potash in these experiments, and there was no evidence that responses to N were increased by giving heavy dressings of K.

2.33 WIDDOWSON, F. V., PENNY, A. & WILLIAMS, R. J. B. (1962). An experiment comparing urea–formaldehyde fertiliser with "Nitro-Chalk" for Italian ryegrass. *J. agric. Sci.* **59**, 263–268.

Italian ryegrass was used in 1958 and in 1959 to compare "single" spring dressings of urea–formaldehyde fertiliser (UF) with equivalent spring dressings of "Nitro-Chalk" (NC), and with "repeated" NC (divided equally between three cuttings). Barley measured residues in 1960. At the first cut each year yields from UF and repeated NC were similar, but later NC gave much larger yields. Aggregate increases from UF were less than half those from equivalent NC. Both forms of nitrogen had residual value for grass and barley. Maximum recovery of N, over 3 years, was 54% for UF and 90% for equivalent NC. Single NC dressings were recovered more completely than repeated dressings. The maximum aggregate uptake over 2 years by grass receiving 2·0 cwt N/acre each year were 72 lb P and 611 lb K/acre.

2.34 WILLIAMS, R. J. B. & COOKE, G. W. (1962). Measuring soluble phosphorus in soils, comparisons of methods, and interpretation of results. *J. agric. Sci.* **59**, 275–280.

Soil samples from 179 field experiments testing phosphate fertilisers on potatoes, swedes and grass were analysed for total phosphorus, and for phosphorus soluble in the following solutions: 0·3*N*-HCl, 0·002*N*-H_2SO_4, 1% citric acid (H_3Ci), 0·5*N*-acetic acid (HAc), acetic acid–sodium acetate buffer (HAc–NaAc) at pH 4·8, 0·5*M*-$NaHCO_3$, and 0·01*M*-$CaCl_2$.

Average values for soluble P were closely related to average crop responses to superphosphate in the experiments on swedes, but not in the grass and potato experiments. The extractants that differentiated best between responsive and unresponsive groups of experiments were HAc, HAc–NaAc and $NaHCO_3$ for potatoes; and HCl, H_2SO_4, HAc–NaAc, $NaHCO_3$ and $CaCl_2$ for grass.

For the experiments as a whole 0·5*M*-$NaHCO_3$ was the "best" extractant. The HCl, H_2SO_4 and HAc–NaAc buffer solution methods were roughly equally effective, though inferior to $NaHCO_3$; the other three extractants (HAc, H_3Ci, $CaCl_2$) were of little general use. Total P in soil was also related to response to superphosphate, though less well than values for soluble P obtained by the better methods.

Estimates of soluble P by different solvents were often related. Estimates by HCl and H_2SO_4 methods were most closely related; values for P soluble in

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H_2SO_4 and in HAc–NaAc were also often significantly correlated, as were estimates by HAc–NaAc and $CaCl_2$. The H_3Ci and $CaCl_2$ methods gave results that were least related to those with other methods.

The use of soil analyses in advising on P-manuring is discussed, and a tentative method is proposed of establishing the analytical limits for soluble P that define "deficient" soils. If the confidence attached to the limiting values that separate "deficient" and "non-deficient" soils is stated farmers will be able to assess the risk entailed in accepting advice based on soil analysis.

Pedology Department

General Paper

3.1 Le Riche, H. H. (1962). Trace elements in soils. *Sci. Progr.* **50**, 285–290.

Research Papers

3.2 Bloomfield, C. (1962). A colorimetric method for determining total sulphur in soils. *Analyst* **87**, 586–589.

The soil is ignited with vanadium pentoxide in a current of nitrogen, and oxidation of volatile organic products completed by passage over hot cupric oxide. Hot metallic copper converts sulphur trioxide to the dioxide, which is absorbed in a solution of sodium tetrachloromercurate and determined colorimetrically with *p*-rosaniline and formaldehyde.

3.3 Greene-Kelly, R. (1962). Charge densities and heats of immersion of some clay minerals. *Clay Min. Bull.* **5**, No. 27, 1–8.

The exchange capacities, surface areas (both external and total) and heats of immersion in water of a selection of clay minerals and a fine-grained muscovite were measured. The charge density (expressed as μ e/m^2) of muscovite was 3·6. This was, as expected, much larger than those of true clay minerals, which tended to group together, the average values being: kaolinites, 2·0; hydrous micas, 1·7; halloysites and montmorillonites, 1·4. The heats of immersion (expressed as joules/m^2) were, in contrast, more widely spread: muscovite, 0·63; halloysites and kaolinites, 0·49; hydrous micas, 0·28; montmorillonites, 0·14. The explanation advanced for the differences in the heats of immersion is that they reflect changes in surface energy and cohesion of the silicate layers, so that expanding minerals which have a small interlayer cohesion have also a small heat of immersion.

3.4 Greene-Kelly, R. (1963). Birefringence of clay mineral complexes. *Clays and Clay Minerals* **10**, 469–475. Pergamon Press.

The birefringence of complexes of montmorillonite with aromatic liquids depends on the type of liquid, and this fact was used to determine the proportion of expanding layers in some partly expanding minerals. A simple method of assessing samples for the presence of expanding minerals could probably be devised on the same lines.

3.5 Ng Siew Kee & Bloomfield, C. (1962). The effect of flooding and aeration on the mobility of certain trace elements in soils. *Plant & Soil* **16**, 108–135.

Iron, cobalt, nickel, zinc, lead, vanadium and molybdenum were mobilised when soils were flooded and incubated anaerobically with plant material. Chromite was unreactive under these conditions, but chromium was mobilised in a soil of normal composition. Molybdenum was mobilised in conditions of increasing acidlty.

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In a well-drained soil copper was mobilised when the soil was incubated with the sole addition of water, but in the presence of added plant material the extractable copper disappeared rapidly, presumably as the result of sorption on plant fibre. In a poorly drained soil of high organic content the water-soluble copper formed in the early stages of incubation also disappeared, but sorption on plant fibre seemed not to be responsible.

Much iron was immobilised when anaerobically incubated soils were aerated, and although drying further decreased the amount of iron extracted, the net result of flooding and redrying was to increase the extractability of iron and the trace metals.

The total amounts of extractable manganese, cobalt and zinc were hardly affected by re-oxidation. In general, re-oxidation decreased the amount of material extracted by water, but this decrease was partly offset by corresponding increases in the fractions extracted by ammonium acetate.

Less molybdenum was immobilised on aeration than would be expected in an inorganic system; coprecipitation with ferric oxide may have been inhibited by the organic matter.

In one instance sorption of nickel on plant fibre caused less nickel to be mobilised when the soil was incubated with whole plant material instead of a plant extract, but the sorbed nickel was liberated on aeration. In a poorly drained soil of high organic content nickel, like copper, seemed not to be affected by the presence of plant fibre.

3.6 WEIR, A. H. & GREENE-KELLY, R. (1962). Beidellite. *Amer. Min.* **47**, 137–146.

The mineral name beidellite has recently fallen into disrepute with mineralogists because specimens so named before the advent of X-ray diffraction techniques proved on re-investigation to be mixtures. The clay from the Black Jack Mine, Idaho, was early described as a beidellite; re-investigation of its properties shows that it is a dioctahedral montmorillonite mineral containing very little magnesium or iron. The term beidellite is retained for the Black Jack Mine mineral, and recommendations are made to clarify its definition.

Soil Microbiology Department

GENERAL PAPERS

4.1 BROWN, M. E. (1962). Populations of Azotobacter in the rhizosphere and effects of artificial inoculation. *Abstracts 8th int. Congr. Microbiol. Montreal*, 53.

4.2 COOPER, R. (1962). The retention of ^{32}P labelled *Rhizobium* by legume seed after inoculation by vacuum treatment. *Abstracts 8th int. Congr. Microbiol. Montreal*, 58.

4.3 MEIKLEJOHN, J. (1962). Nitrifying bacteria in soils in Britain and Ghana. *Abstracts 8th int. Congr. Microbiol. Montreal*, 59.

4.4 MOSSE, B. (1963). Vesicular–arbuscular Mycorrhiza: an extreme form of fungal adaptation. *In* Symbiotic Associations. *13th Symp. Soc. gen. Microbiol*, 146–170.

4.5 NUTMAN, P. S. (1963). Factors influencing the balance of mutual advantage in symbiosis. In Symbiotic Associations. *13thSymp. Soc. gen. Microbiol*, 51–71.

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4.6 NUTMAN, P. S. (1962). Normal and abnormal patterns of root-hair infection by *Rhizobium trifolii*. *Abstracts 8th int. Congr. Microbiol. Montreal*, 58.

4.7 NUTMAN, P. S. (1963). Symbiotic nitrogen fixation in soil nitrogen. *American Society of Agronomy Monograph*. (In the press.)

4.8 WALKER, N. & (CLAUS, D.) (1962). The decomposition of toluene by a soil bacterium. *Abstracts 8th int. Congr. Microbiol. Montreal*, 63.

RESEARCH PAPERS

4.9 BROWN, M. E., BURLINGHAM, S. K. & JACKSON, R. M. (1962). Studies on Azotobacter species in soil. 2. Populations of Azotobacter in the rhizosphere and effects of artificial inoculation. *Plant & Soil*. **17**, 320–332.

The distribution of Azotobacter was studied in the rhizosphere of some crop plants grown in this country. Any rhizosphere effect was very small, and frequently Azotobacter was suppressed. No cells were recovered from root washings, indicating absence from the root surface. Azotobacter was absent from the rhizosphere in acid soils.

Inoculation of seeds, roots and soil resulted in establishment of many Azotobacter in the rhizospheres of plants grown in soil of pH above 6·5 and containing a natural Azotobacter population. Seed inoculation was the most practical, and led to good establishment throughout the root system, including adventitious roots of wheat. The final population in the rhizosphere depended on the size and age of the initial inoculum applied to the seed. Best results came from spraying seed with 14-day-old cultures and sowing the seed on the same day.

4.10 GUPTA, B. M. & KLECZKOWSKA, J. (1962). A study of some mutations in a strain of *Rhizobium trifolii*. *J. gen. Microbiol.* **27**, 473–476.

Mutants of a strain of *Rhizobium trifolii* were obtained by selective action of bacteriophage and streptomycin and by exposure to ultra-violet radiation. All mutants resistant to bacteriophage were streptomycin-susceptible, and all resistant to streptomycin were bacteriophage-susceptible; no survivor after exposure to the radiation resisted either the bacteriophage or streptomycin. Mutation to bacteriophage resistance was closely correlated with inability to fix nitrogen in symbiosis with red clover. Some streptomycin-resistant mutants used streptomycin as a nutrient supplement, enabling them to grow on a mineral medium without growth factors. All but two mutants remained serologically indistinguishable from the original strain.

4.11 PARLE, J. N. (1963). Micro-organisms in the intestines of earthworms. *J. gen. Microbiol.* (In the press.)

Actinomycetes and bacteria, but not fungi, increase rapidly in numbers during the passage of food through the worm gut. Enzymes produced by the worm rather than micro-organisms seem to be the main agents digesting cellulose and chitin. The rate material moves through the intestine depends on whether the animal is feeding; food takes about 20 hours to pass, but when burrows are being formed material passes in about 12 hours.

4.12 PARLE, J. N. (1963). A microbiological study of earthworm casts. *J. gen. Microbiol.* (In the press.)

Microbiological, physical and chemical changes were followed in worm casts ageing in the field. Filamentous fungi and yeasts increase in number rapidly after the cast is produced, but not bacteria or actinomycetes which are initially

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numerous. Measurements of hyphal length confirmed the increased growth of fungi. Ageing casts show a declining respiratory activity, possibly because the bacteria form resting stages. Aggregate stability increases rapidly as casts age, probably because amounts of fungal hyphae increase. Casts contain much more polysaccharide than soil, but amounts did not change with changes in stability. Casts contained much more total and mineral nitrogen than soil; the major part of the inorganic nitrogen occurred as ammonia, which was rapidly converted to nitrate.

Botany Department

General Paper

5.1 Humphries, E. C. & Wheeler, A. W. (1963). The physiology of leaf growth. *Annu. Rev. Pl. Physiol.* **14** (In the press).

Research Papers

5.2 Humphries, E. C. (1963). Dependence of net assimilation rate on root growth of isolated leaves. *Ann. Bot., Lond. N.S.* **27**, 175–184.

The phenomenon of inhibition of assimilation by carbohydrate accumulation was re-investigated, using single-rooted leaves of dwarf French bean. This system has the advantage that the assimilating area remains constant and carbohydrate is translocated to a single sink—the root system. The net assimilation rate of the system did not vary with season and was small compared with that of intact plants in the summer; apparently it is restricted by an internal factor. This factor is the rate of translocation of carbohydrate from source to sink (from lamina to root), which in turn depends on the growth rate of the root system. The net assimilation rate increased when root growth was increased, by increasing the volume of the culture vessel, by preliminary treatment with IAA or by raising the root temperature. It was decreased when root growth was retarded by kinetin treatment.

In glasshouse experiments lamina dry matter increased by 0·75 mg/cm²/week, to a maximum that depended on the time of year; in August it was more than 7·0 mg/cm², but there was a seasonal trend. When the roots were held at 24° carbohydrate accumulated in the lamina more slowly than at lower temperatures.

5.3 Orchard, B. (1963). The growth response of sugar beet to similar irrigation cycles under different weather conditions. *Brit. Ecol. Soc. Symposium on "The Water Relations of Plants"*. Oxford: Blackwell Scientific Publications, pp. 344–359.

Sugar beet grown in covered field plots showed a similar response to long drought (July–September) in two successive years in spite of differences in net radiation and evaporation rate. A similar drought in autumn (September–January) had no significant effect. A short drought earlier in the growth period (June–July) had a greater effect than the long drought.

During drought leaf growth was restricted, and eventually the dry weight yield was depressed. The net assimilation rate was unaffected during drought. When the drought was broken the leaf growth rate was significantly enhanced, and in one experiment the net assimilation was also increased. This last seems to require a high daily radiation and a leaf-area index below about 1·5.

5.4 Thorne, G. N. (1963). Varietal differences in photosynthesis of ears and leaves of barley. *Ann. Bot., Lond. N.S.* **27**, 155–174.

Rates of apparent photosynthesis of ears, and of shoots (combined flag leaf and sheath and peduncle), of Proctor barley grown in pots or in the field were

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similar to those of Plumage Archer, or slightly smaller. The photosynthetic rate of the ear, about 1·0 mg CO_2/hour/ear, was similar to, or slightly less than, the rate of the shoot. 40–50% of the carbohydrate in the grain was provided by photosynthesis in the shoot, and about 40% by photosynthesis in the ear. Shading the ear underestimated the total amount of CO_2 fixed by the ear and decreased dry weight of grain per ear of both varieties by 26%. The contribution of ear photosynthesis to yield of grain per acre was greater for Proctor than for Plumage Archer, because Proctor had more ears.

The rate of apparent photosynthesis per dm^2 of leaves of Proctor was similar to that of Plumage Archer, both before and after ear emergence. Before ear emergence the photosynthetic rate of a particular leaf decreased linearly with time, and was less for lower than for higher leaves on the shoot.

5.5 THORNE, G. N. (1963). Distribution of dry matter between ear and shoot of Plumage Archer and Proctor barley grown in the field. *Ann. Bot., Lond. N.S.* **27**, 185–192.

In a field experiment where Proctor barley yielded slightly more grain than Plumage Archer but had similar total dry weight, the dry weight ratio of ear to shoot was greater for Plumage Archer than for Proctor at ear emergence and greater for Proctor at maturity, as in a previous pot experiment. When ears were shaded the ear : shoot dry-weight ratio at maturity of Proctor was not significantly greater than that of Plumage Archer. The varietal difference in ear : shoot ratio was reversed because ears of Proctor had a greater relative growth-rate than ears of Plumage Archer, apparently because they photosynthesised more. Proctor shoots decreased in weight slightly less than shoots of Plumage Archer.

5.6 THURSTON, J. M. (1962). An international experiment on the effect of age and storage conditions on viability and dormancy of *Avena fatua* seeds. *Weed Res.* **2**, 122–129.

Freshly collected ripe seeds of *Avena fatua* were first kept out of doors on the surface of the soil for 0–3 months, and then stored dry in the laboratory for 0–6 months before testing for dormancy and viability. Results from six European countries agreed well. Only 10% of ripe seeds germinated immediately after collection, and germination rose to 50% by December or January in all countries except Denmark. Viability was scarcely affected by age or storage conditions, except that many seeds died out of doors during winter in Denmark and Germany. The percentage of dormant seeds in December was greater in Denmark than elsewhere, possibly because the seeds were of a different type. Seeds may not behave the same in normal agricultural conditions as they did in this experiment.

5.7 THURSTON, J. M. (1962). The effect of competition from cereal crops on the germination and growth of *Avena fatua* L. in a naturally-infested field. *Weed Res.* **2**, 192–207.

The effect of winter wheat, winter rye, winter barley, spring barley, and fallow cultivated as for a winter cereal, on germination and growth of wild oats (*Avena fatua*) was investigated on a naturally infested field. Treatments were continued for 2 years on the same plots, and in the third year all plots were cropped with spring barley. Wild oats were not allowed to shed seeds.

A. fatua was controlled by a dense crop of an autumn-sown cereal. The crop genus was unimportant, provided it grew well on the site; its effectiveness depended on its density when the wild oats germinated in spring. Winter wheat and winter rye were equally effective. Even in a light crop of barley, wild oats

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grew much less vigorously than on the fallow plots. Beyond a certain crop density, dependent on soil fertility, further increases in crop did not decrease the size of wild oat plants. The heaviest crop did not completely suppress the wild oats.

The crop affected the wild oats mainly by decreasing growth of the seedlings, but under winter wheat and winter rye some wild oat seeds may have remained dormant, germinating in the spring barley in the third year, perhaps because the heavy crops decreased the soil moisture content. Nitrogenous fertiliser increased the weight of both crops and wild oats. Barley was more severely affected by soil acidity than wild oats, and on acid areas of barley plots the wild oats were larger than where the pH was higher. In wheat and rye, which were scarcely affected by soil acidity, the size of the wild oat plants was unaffected by soil pH.

5.8 WATSON, D. J., THORNE, G. N. & FRENCH, S. A. W. (1963). Analysis of growth and yield of winter and spring wheats. *Ann. Bot., Lond. N.S.* **27**, 1–22.

In a field experiment to investigate the physiological causes of variation in yield between autumn- and spring-sown wheat and between old and new varieties, the grain yields of the winter wheats were 3–15% greater than of the spring ones and the new varieties Cappelle-Desprez and Jufy I yielded 40–70% more than Squarehead's Master and Atle. Nitrogen fertiliser increased the yields of Cappelle-Desprez and Jufy I more than of Atle, and decreased the yield of Squarehead's Master by making it lodge.

Until ear emergence the winter varieties had greater leaf area indices (L) and dry weights, but smaller net assimilation rates (E), than the spring varieties. Squarehead's Master had greater L but smaller E, and similar dry weight to Cappelle-Desprez. Jufy I had similar E to Atle, but greater L and dry weight. Nitrogen increased L and dry weight, but decreased E. All the differences in E between varieties and nitrogen treatments could be explained by the opposite effects on L, that is to say, the differences in E were caused by variation in mutual shading arising from the differences in L, and not by changes in leaf physiology.

L of winter wheat reached its maximum at the end of May, but L of spring wheat continued to increase until ear emergence. Afterwards L decreased more rapidly for winter than for spring wheat, so that eventually spring wheat had the greater L. These differences in the time changes of L partially compensated for the shorter growth period of spring wheat, and tended to equalise the grain yield from winter and spring sowings.

After ear emergence total dry weight of winter varieties continued to be greater than of spring ones, but the difference in dry weight of ears was much smaller because ear : shoot dry weight ratio was greater for the spring varieties. Total dry weight, ear dry weight and ear : shoot ratio were all greater in the new than in the older varieties. Leaf area duration (D) after ear emergence was slightly greater for the winter than for the spring varieties, and similar for old and new. The apparent efficiency of this leaf area in grain production, measured by the grain leaf ratio (ratio of grain dry weight to D), was similar for winter and spring varieties, but greater for new than for old. This suggests that Cappelle-Desprez and Jufy I have higher grain yields because their ears photosynthesise more than do the ears of Squarehead's Master and Atle.

Before ear emergence winter varieties had more shoots than spring ones, and old varieties more than new. After ear emergence there were only small differences in numbers of ears; percentage survival was greater for spring than for winter and for new than for old varieties.

Differences in dry weight between varieties were not caused by differences in nitrogen uptake.

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5.9 WELBANK, P. J. (1963). A comparison of competitive effects of some common weed species. *Ann. appl. Biol.* **51**, 107–125.

Single plants of kale, sugar beet or wheat were grown alone and with 16 plants of different weed species at two N levels for from 7 to 11 weeks in four pot experiments. The competitive abilities of the weeds, measured by their effects on dry weight growth of the crop species, were expressed as a percentage of the effect of *Chenopodium album* in the same experiment, to allow for differences between experiments. The descending order of competitive abilities obtained with kale was: *Sinapis arvensis*, then *Polygonum convolvulus* and *Alopecurus myosuroides*, then *Chenopodium album*, *Polygonum aviculare* and *Polygonum persicaria*, followed by *Matricaria maritima* ssp. *inodora*, finally *Stellaria media*, *Capsella bursa-pastoris*, *Veronica persica* and *Anagallis arvensis*. With other crops the weed effects were similar, except that with wheat *Polygonum convolvulus* had less competitive ability than *Alopecurus* and about the same as *Chenopodium* and *Polygonum aviculare*, and *Matricaria* had about the same value as *Veronica*.

Competition for N contributed to the effects of most weeds on kale and sugar beet, but apparently only to the effects of *Sinapis* and *Alopecurus* on wheat. Factors other than N contributed largely to the effects of *Chenopodium*, *Polygonum convolvulus* and *Sinapis* on kale or sugar beet, and to a lesser extent to the effects of other weeds.

Weed yields were usually depressed by adding a single indicator plant to their pots, the depression was least in weeds which themselves most affected indicator growth.

The results probably indicate reasonably well the importance of the weeds as competitors with crops, for which purpose the method used has advantages over other ways of estimating relative competitive ability.

5.10 WHEELER, A. W. & HUMPHRIES, E. C. (1963). Effect of gibberellic acid on growth, gibberellin content, and chlorophyll content of leaves of potato (*Solanum tuberosum*). *J. exp. Bot.* **14**, 132–136.

Spraying potato plants with a solution of gibberellic acid (GA) when the 15th leaf was emerging increased the area of this leaf and its total gibberellin content, assayed by dwarf French bean leaf disks. GA, assayed by lettuce hypocotyls, was not detected in leaves from untreated plants. The GA content of the 15th leaf from GA-treated plants decreased after 2 weeks, and none was detected after 5 weeks; apparently it was converted to another gibberellin, possibly the same as the natural gibberellin. GA increased the chlorophyll content per leaf, but increased leaf area more, so that the leaves were paler than untreated ones.

Biochemistry Department

GENERAL PAPERS

6.1 PIRIE, N. W. (1962). Future sources of food supply: scientific problems. *J. R. statist. Soc. Ser. A*, **125**, 399–417.

6.2 PIRIE, N. W. (1962). Patterns of assumption about large molecules. *Arch. Biochem. Biophys.* Suppl. 1, 21–29.

6.3 PIRIE, N. W. (1962). Produzione e uso di proteine delle foglie per l'alimentazione umana. *Symp. on food quality*, Bari.

6.4 PIRIE, N. W. (1963). Unconventional protein sources. *Encyclopaedia Britannica Book of the Year.*

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6.5 PIRIE, N. W. (1963). Non-conventional protein sources. In: *Biochemistry and biophysics in food research*, pp. 87–99. Butterworths.

6.6 PIRIE, N. W. (1963). Freeze-drying or drying by sublimation. In: *Instrumentation in experimental biology*. ed. D. W. Newman. USA: Macmillan.

RESEARCH PAPERS

6.7 DAVYS, M. N. G. & PIRIE, N. W. (1963). Batch production of protein from leaves. *J. agric. Engng Res.* **8**, 70–73.

A unit is described that pulps and presses fresh leaves in one operation and yields an extract from which protein can be prepared. It can take up to 500 lb of leaf and finish the extraction in 1–2 hours when consuming 1–1·5 hp. The unit consists of a perforated circular table round which a ribbed roller is driven either by a motor mounted on the machine or by pulley and belt drive. The leaves are put on the table, and the action depends both on shear between the roller and the table and also on the tearing action of the ribs as the roller climbs up the mass of leaf in front of it. At the same time the weight of the roller and the assembly carrying it presses through the perforations the juice that has been liberated.

6.8 HILL, J. M. & MANN, P. J. G. (1962). The inhibition of pea-seedling diamine oxidase by chelating agents. *Biochem. J.* **85**, 198–207.

Investigations of the inhibition of the diamine oxidase of pea seedlings by 2,2′-bipyridyl, 1,10-phenanthroline, 8-hydroxyquinoline, potassium ethyl xanthate and sodium diethyldithiocarbamate showed that the inhibitions depend on the copper complexing properties of these reagents. The primary reaction is the combination of the reagents with enzyme-bound copper to form inactive enzyme–inhibitor complexes. A secondary increase in inhibition on incubation with sodium diethyldithiocarbamate was due to removal of copper from the enzyme. The enzyme was not inhibited by neocuproine, a reagent specific for cuprous copper, and no cuprous copper was found in the enzyme by the biquinoline estimation method. It was concluded that the diamine oxidase is a metalloenzyme containing cupric copper.

6.9 SINGH, N. (1962). Proteolytic activity of leaf extracts. *J. Sci. Fd Agric.* **13**, 325–332.

The autolysis of proteins in leaf extracts and the proteolytic activity of crude preparations from such extracts against casein, as added substrate, was studied. If the proteins are not precipitated soon after preparation of extracts they autolyse, and the loss from autolysis is directly related to the temperature and to the interval between preparing the extract and precipitating proteins. The advantages of the use of the NPN-increment over other methods as an index of protein hydrolysis are discussed. This method was used to study the proteolytic activity of leaf extracts from 11 plant species free from latex. Leaf proteases from these plants form a homogeneous group with little activity per g of protein -N, and evidence is given suggesting that they belong to the SH-group of enzymes with optimum pH between 5·2 and 5·7. Protease activity per g of protein N increases in the leaves of wheat during the transformation of the shoot apex from vegetative into reproductive state.

Plant Pathology Department

THESES

7.1 BABOS, P. (1962). The properties and behaviour of tobacco necrosis viruses. Ph.D. Thesis, University of London.

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7.2 CLOSE, R. C. (1962). Some interactions between viruses when multiplying together in plants. Ph.D. Thesis, University of London.

7.3 DIAS, H. F. (1962). Sap-transmissible viruses of grapevines. Ph.D. Thesis, University of London.

7.4 LACEY, J. (1962). The activity of *Phytophthora infestans* (Mont.) de Bary in soil. Ph.D. Thesis, University of Reading.

7.5 RAM REDDY, M. A. (1962). A study of the effects of disease control measures on the soil microflora of Sitka spruce (*Picea sitchensis*) in forest nurseries. Ph.D. Thesis, University of London.

GENERAL PAPERS

7.6 BAWDEN, F. C. (1963). The role of research in the development of modern agriculture. *Proc. XI int. Congr. Sug. Cane Technol.* 1962, pp. 17–24.

7.7 BAWDEN, F. C. (1963). Plant viruses: their nature and control. *Span* **6**.

7.8 GREGORY, P. H. (1962). Outdoor aerobiology. *Rep. Smithson. Instn*, 1961, 445–453.

RESEARCH PAPERS

7.9 BABOS, P. & KASSANIS, B. (1962). Unstable variants of tobacco necrosis virus. *Virology* **18**, 206–211.

From single lesions caused by two strains of tobacco necrosis virus variants were isolated that were unstable in sap and difficult to maintain by inoculation with sap. Extracts of leaves infected with these variants in water-saturated phenol or in 0·5*M*-borax pH 9·2, were 10–100 times more infective than sap. The results are consistent with the idea that the unstable variants occur in the plant largely as nucleic acid, which is destroyed by leaf ribo-nuclease when the leaves are ground in conditions that allow the enzyme to act. Although most of the infectivity of these variants resides in unstable particles, many, if not all, populations contain some stable particles, presumably composed of nucleoprotein, which retain their infectivity in sap and survive purification procedures. About 1 in 20 of the lesions formed by purified preparations of the two strains of tobacco necrosis virus yielded the unstable variant only. During repeated transmission in series the unstable variant did not give rise to stable ones. The satellite virus that multiplies only in leaves simultaneously infected with certain strains of tobacco necrosis virus, multiplied in leaves infected with the unstable variant, but less extensively than with the stable variant.

7.10 BAILEY, L. & GIBBS, A. J. (1962). Cultural characters of *Streptococcus pluton* and its differentiation from associated enterococci. *J. gen. Microbiol.* **28**, 385–391. (For summary see No. 11.5)

7.11 (BROADBENT, L.), HEATHCOTE, G. D. & (WRIGHT, R. C. M.) (1962). Home-production of seed for early potatoes. 4. Loss of yield in virus-infected plants. *Exp. Hort.* **7**. (In the press.)

A stock of early potatoes, variety Ulster Prince, was kept productive for 8 years when sprayed with insecticide and rogued. Losses in weight of ware and seed tubers averaged 69% from infection with virus Y, 41% with leaf roll and 30% with virus X.

7.12 BUXTON, E. W. (1962). Root exudates from banana and their relationship to strains of the *Fusarium* causing Panama wilt. *Ann. appl. Biol.* **50**, 269–282.

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A method is described for obtaining sterile exudates from banana roots still attached to the parent plant. Root exudates from the varieties Gros Michel (susceptible to Panama wilt) and Lacatan (resistant) were tested for their effects on spore germination of three strains of the pathogen, *Fusarium oxysporum* f. *cubense*.

In a medium otherwise optimal for spore germination, root exudates from Lacatan plants 3–6 months old inhibited spore germination, whereas those from Gros Michel did not. The extent of the inhibition depended on the strain of the *Fusarium* tested and decreased with increasing age of the plants. In weak sucrose or soil-extract media, root exudates from Gros Michel promoted spore germination of each strain. Exudates from Lacatan plants older than 6 months promoted germination in these two media, but less than Gros Michel exudates.

Chromatograms showed 18 amino acids in the root exudates, 13 common to both banana varieties. Gros Michel exudates contained no detectable cystine or threonine, and Lacatan no leucine, serine or tyrosine. Root exudates from young Lacatan contained more aspartic acid, glutamine and proline than those from young Gros Michel, but the differences decreased as the plants aged.

Total carbohydrates were maximal in root exudates from 6-month-old plants of both varieties. Gros Michel had 1·5 times more carbohydrate than Lacatan when young, but plants 3 and 9 months old contained almost equal amounts. Chromatograms showed eight sugars, all more abundant in Gros Michel than in Lacatan exudates.

Materials that inhibited spore germination on Dox-agar media were demonstrated at R_F 0·7 on chromatograms of Lacatan exudates. Neither ninhydrin-reactive spots nor spots that fluoresced under ultra-violet light occurred at R_F 0·7 with Gros Michel exudates; nor did any materials at that R_F inhibit spore germination.

The relationships between materials in the root exudates from the wilt-susceptible and wilt-resistant plants and differences in spore germination responses are considered as part of a wilt-resistance mechanism in the rhizosphere of banana.

7.13 BUXTON, E. W. (1962). Parasexual recombination in the banana-wilt *Fusarium*. *Trans. Brit. mycol. Soc.* **45**, 274–279.

Three strains of *F. oxysporum* able to wilt the banana variety Gros Michel (*Musa-AAA* group) were irradiated with ultra-violet light to produce genetic markers that allowed them to be identified in culture by nutritional deficiencies. Heterokaryons that formed between the strains produced a few prototrophic spores with wild-type growth rates.

Progeny from 3,036 subcultures of the prototrophic, and presumed diploid, conidia could be divided into three classes: daughter diploids (99·3%), haploid parentals (0·2%) and recombinant haploids (0·5%). Further recombination occurred with additional genetic markers that differentiated the strains by their differences in haemaglutinating properties with human blood group O and by differences in pathogenicity for *M. balbisiana*.

The banana-wilt *Fusarium* can undergo genetic recombination by an asexual method similar to the parasexuality in some other imperfect fungi. The implications of this in relation to banana breeding for wilt resistance and to problems of cultural variation in *Fusaria* from banana are discussed.

7.14 BUXTON, E. W. & HASTIE, A. C. (1962). Spontaneous and ultra-violet irradiation-induced mutants of *Verticillium albo-atrum*. *J. gen. Microbiol.* **28**, 625–632.

The killing of conidia of *Verticillium albo-atrum* by ultra-violet irradiation followed first-order kinetics; about 0·5% of the conidia which survived at 97%

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lethal dose were nutritionally deficient mutants. This percentage of mutants among survivors was constant for different wild-type isolates for the first-, second- and third-order irradiations. This regularity implies that most conidia exposed at the first irradiations contained a single haploid nucleus. Adenine-requiring mutants formed pionnotes when grown on an agar medium containing little adenine, and the extent of pionnotal formation depended on the position at which adenine synthesis had been blocked by the irradiation. 4-Aminoimidazole-5-carboxamide apparently did not act as an extracellular intermediary in adenine synthesis. An acriflavine-resistant mutant arose spontaneously in one of the mutants selected for nutritional deficiency, but mutants resistant to certain other growth inhibitors were not found.

7.15 BUXTON, E. W., SINHA, INDU & WARD, V. (1962). Soil-borne diseases of Sitka spruce seedlings in a forest nursery. *Trans. Brit. mycol. Soc.* **45**, 433–448.

Seedlings of Sitka spruce (*Picea sitchensis* Carr.) growing at Old Kennington forest nursery, Oxford, showed a succession of troubles in 1959; damping-off in spring, browning of leaves and roots in summer, and stunting without root damage in autumn. Affected plants occurred on experimental plots treated with formalin each year for 5 years, whereas plants grew normally on adjacent plots treated only once with formalin.

The microfloras of the rhizosphere and of seedling roots were examined at 12-day intervals from early May to October. Only 13 genera of fungi were identified in plots treated annually with formalin; the most prevalent were *Pythium* spp., *Fusarium oxysporum*, *F. roseum*, *Penicillium* spp. and *Trichoderma viride*. The frequency in the rhizosphere of *Pythium* spp., of bacteria and, to a lesser extent, of *F. oxysporum* decreased as the season advanced, whereas *Trichoderma viride*, *Penicillium* spp., *F. roseum* and *Bacillus cereus* var. *mycoides* increased.

Pathogenicity tests with 96 isolates of fungi and bacteria showed that damping-off was caused by *Pythium* spp. and browning by *F. oxysporum*; some isolates of *F. oxysporum* caused stunting, as also did *F. roseum*. Isolates of *Pythium* and *Fusarium* made early in the season were more pathogenic than those isolated later.

The prolific rhizosphere microflora in the formalin-treated plots may result partly from the introduction of fungi and bacteria on seed, which by plating on agar media was shown to be contaminated. However, many isolates of *Pythium* and *Fusarium* and a few of *Gliocladium roseum*, *Mortierella* and *Penicillium* from formalin-treated soil also tolerated high levels of formalin in agar media. Isolates of *F. oxysporum* from adjacent soils untreated with formalin were less tolerant, suggesting that tolerance may have developed as a result of repeated treatment.

7.16 BUXTON, E. W. & WARD, V. (1962). Genetic relationships between pathogenic strains of *Fusarium oxysporum Fusarium solani* and an isolate of *Nectria haematococca*. *Trans. Brit. mycol. Soc.* **45**, 261–273.

The *Fusarium* state of an isolate of *N. haematococca* Berk. & Br. that occurred in a mutant culture of *F. oxysporum* readily formed stable heterokaryons with isolates of *F. o.* f. *pisi*, *lycopersici*, and f. *cubense* and *F. solani* f. *pisi* and f. *phaseoli*. This indicates a close genetical relationship between these Fusaria and between them and *N. haematococca*, which, like *F. oxysporum* f. *pisi*, causes wilt of Onward pea. Heterokaryons also formed between different *formae speciales* of pathogenic *F. oxysporum*.

In addition, genetic crossing was achieved in culture between the *Nectria* and four strains of *F. o.* f. *pisi* and with two of *F. o.* f. *lycopersici*. Nutritional deficiencies induced by ultra-violet irradiation, wild-type differences in perithecial

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production and differences in pathogenicity for pea or tomato were used as genetic markers. In 1931 random single-ascospore cultures from single perithecia resulting from crosses, recombinations were demonstrated between the *Nectria*, the isolates of *F. oxysporum* and those of *F. solani*. All three types of markers, including specific pathogenicity, were interchangeable between the parentals of each cross.

Single-ascospore cultures from perithecia arising on colonies from spore mixtures of *F. oxysporum* and conidial *Nectria* produced perithecia in 48–94% of the colonies, depending on which *F. oxysporum* strain was used as parent, whereas single-ascospore colonies from the homothallic *Nectria* were always perithecial. When *Nectria* was crossed with a mildly virulent mutant of *F. o.* f. *pisi* the resulting single-ascospore cultures had a decreased ability to cause wilt.

Crossing *Nectria* with *F. s.* f. *pisi* indicated that, although several cultural characters were recombined, no recombination occurred between the ability to cause pea wilt (*Fusarium* state of *Nectria*) and the ability to cause foot rot (*F. solani*). This may mean that these abilities are either genetically allelic or closely linked; hence, a distinction that can be made between the two Fusaria by means of pathogenicity tests is likely to be more reliable than any comparisons of cultures. These results do not necessarily imply that *N. haematococca* is the wild-type perfect state of *F. oxysporum* or of *F. solani*.

7.17 Cox, J. & (Cock, L. J.) (1962). Survival of *Cercosporella herpotrichoides* on naturally infected straws of wheat and barley. *Plant Path.* **11**, 65–66.

In 1957 and 1959 the average number of spore-producing straws on the soil after a susceptible crop ranged from 27·4 to 1·4 per sq yard, but a year later was never more than 1·1. The incidence of eyespot in April was closely related to the amount of sporing material on the soil during late winter.

7.18 Dias, H. F. (1963). Host range and properties of grapevine fanleaf and grapevine yellow mosaic viruses. *Ann. appl. Biol.* **51**, 85–95.

Sap-transmissible viruses were obtained from grapevines affected by fanleaf, yellow mosaic, distorting mosaic, witches' broom or fasciation diseases. American, Australian, French and Portuguese grapevines contained similar viruses. Herbaceous hosts of viruses from grapevines with fanleaf or yellow mosaic included 32 species in five plant families; yellow mosaic isolates usually caused distinctive symptoms in systemically infected leaves of *Chenopodium amaranticolor*, but in many other hosts could not be distinguished from fanleaf isolates. Yellow mosaic and fanleaf diseases were each reproduced by transmitting the isolates back to grapevine from *C. amaranticolor*. Grapevine fanleaf and grapevine yellow mosaic viruses were both transmitted through seed of *C. amaranticolor*; both were precipitated without inactivation by ethanol, by acetone, by ammonium sulphate and at pH 5. Preparations of each, partially purified from systemically infected leaves of *Nicotiana clevelandii*, contained polyhedral particles about 30 mμ in diameter. Phenol-disrupted virus was 1–5% as infective as its parent virus suspensions.

7.19 Dias, H. F. & Harrison, B. D. (1963). The relationship between grapevine fanleaf, grapevine yellow mosaic and arabis mosaic viruses. *Ann. appl. Biol.* **51**, 97–105.

Plant-protection and serological tests showed that the viruses causing fanleaf and yellow mosaic of grapevine in Portugal, Switzerland and the United States are closely related strains. These strains and arabis mosaic virus cause similar symptoms in many herbaceous species, but arabis mosaic virus is more virulent

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and more often becomes systemic. Attempts to transmit arabis mosaic virus to grapevine failed. Arabis mosaic virus shares only few antigenic determinants with the viruses obtained from grapevine, and these viruses do not protect plants against it. In a virus classification the grapevine virus isolates and arabis mosaic virus can be considered two distinct serotypes of one virus.

The nematode *Xiphinema diversicaudatum* acquired arabis mosaic virus and transmitted it to herbaceous plants, but did not transmit the grapevine viruses. As *X. index* transmits grapevine fanleaf virus and probably transmits grapevine yellow mosaic virus, this suggests specific transmission of virus serotypes by different species of nematodes.

7.20 GIBBS, A. J. (1962). Lucerne mosaic virus in British lucerne crops. *Plant Path.* **11**, 167–171.

Lucerne mosaic virus (LMV) was found in shoots from 52 out of 76 lucerne crops sampled in different parts of Great Britain in 1959, although only 11% of all the shoots tested were infected. The incidence of LMV was similar in different parts of Great Britain, but it was greater in old crops than in young, and in crops of small than of large area. Plots of lucerne in which 75% of the plants were infected yielded 10% less in a year than comparable plots with 20% of the plants infected. Most of the effect on yield was in the spring, when symptoms of the disease were most noticeable.

7.21 GLYNNE, M. D. (1963). Eyespot (*Cercosporella herpotrichoides*) and other factors influencing yield of wheat in the six-course rotation experiment at Rothamsted (1930–60). *Ann. appl. Biol.* (In the press.)

Yeoman wheat in the six-course rotation experiment (potatoes, rye, sugar beet, barley, clover, wheat) at Rothamsted averaged between 1937 and 1960 34% of straws at harvest infected, 19% severely, with *Cercosporella herpotrichoides*, the cause of eyespot. In different years infected straws ranged from 2 to 99%, which included 1–81% with severe lesions. Straws severely infected increased by about 7% in each succeeding 6-year cycle, presumably because the amount of infectious material steadily increased. The small amount of eyespot at the beginning of the experiment can be explained by the few cereal crops taken on the land before the experiment began. The fungus survived 5 years between wheat crops, partly on spring-sown barley and autumn-sown rye, which (1952–60) each averaged 8% infected straws, only 2% severely, whereas wheat had 45% infected, 27% severely.

Other factors that probably influenced yield in some years include lodging (which occurred in 10 years, when straw yield or severe eyespot were above average), other diseases and pests, notably wheat-bulb fly, weeds, and differences in cultivations and treatments.

Mean yield of grain in the 30 years was 28·5 cwt/acre, the maximum 41·1, minimum 18·7. In a neighbouring field Yeoman wheat, unharmed by soil-borne diseases and pests and given the same amount of nitrogen (0·6 cwt/acre), yielded about 40 cwt/acre with a year-to-year variance of only 5 cwt/acre, compared with a range of 19·1 cwt/acre in the six-course wheat in the same period (1952–58), the same weather thus having different effects on healthy and diseased wheat.

The number of straws/ft row (adjusted to 7-in. spacing) averaged annually 21·3 (maximum 28·0, minimum 14·8). Regression analyses showed that 18% of the variance in grain yield was accounted for by the number of straws and that when the number with severe eyespot lesions was included as a depressing factor, together they accounted for 48%. These figures further indicate that severe infection of all straws would almost halve the yield and that the mean loss attributable to severe eyespot lesions at harvest (1942–60) was about 12%.

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7.22 GREGORY, P. H. (1962). Identity of organised elements from meteorites. *Nature, Lond.* **194**, 1065.

Published illustrations show that some of the organised elements from the Orgueil and Ivuna meteorite resemble known plant spores, and the possibility that they have a terrestrial origin must be considered.

7.23 GREGORY, P. H. & LACEY, M. E. (1962). Isolation of thermophilic actinomycetes. *Nature, Lond.* **195**, 95.

Thermophilic actinomycetes have been difficult to isolate from liquid suspensions. A method is described in which dry actinomycete spores are suspended in air and are then impacted on to surface-dried medium in Petri dishes in an Andersen sampler.

7.24 GREGORY, P. H. & LACEY, M. E. (1963). Mycological examination of dust from mouldy hay associated with farmer's lung disease. *J. gen. Microbiol.* **30**, 75–88.

Small samples of hay were shaken in a perforated drum in a wind of 4·2 m/sec; the liberated dust cloud was sampled with the cascade impactor for microscopical examination, and with the Andersen sampler for identification of organisms in culture. The results of testing batches of hay showed large differences in microbial content. Twenty-eight batches classed as "good hay" gave up to 3 million spores/g dry wt hay, mainly *Aspergillus glaucus* with *Cladosporium* spp. and *Hemispora stellata*. Dust blown from 17 batches of "mouldy hay" differed greatly in composition and had from 5 to 250 million spores/g: abundant forms included *A. glaucus*, *A. fumigatus*, *A. nidulans*, *Penicillium* spp., *Absidia* spp., *Mucor pusillus*, bacteria, many actinomycetes. Fourteen batches of mouldy hay associated with cases of "farmer's lung" disease were generally similar in mould content to the batches of mouldy hay, but had many more spores of *Humicola* (*Monotospora*) *lanuginosa* and *A. fumigatus*, and were especially characterised by very many actinomycetes. Farmer's lung hays tended to neutrality (averaging pH 7·0, as compared with pH 5–6 of other hays), and were rich in thermophilic organisms, commonly with hundreds of millions of actinomycete spores/g, a large proportion of which grew readily at 60°. Hays associated with farmer's lung appear to have heated spontaneously to a higher temperature during maturation than the other hays. Dust from all hays contained particles of higher plants, but there were not obviously more in farmer's lung than in other hays. All types of spores were shown to be potentially able to penetrate to the deeper parts of the lung (especially the spores of actinomycetes, *A. fumigatus* and *H. stellata*), but whether these organisms play any part in the aetiology of the disease is unknown.

7.25 HARRISON, B. D. & HOOPER, D. J. (1963). Longevity of *Longidorus elongatus* (de Man 1876) and other nematodes in soil kept in polythene bags. *Nematologica* **9**. (In the press.)

Adult *L. elongatus* survived better than larvae when moist soil was kept in bags without plants for 29 months at about 18°. Most survivors were able to feed on cucumber roots. Other surviving nematodes included *Pratylenchus crenatus* and *Tylenchorynchus dubius*.

7.26 HEATHCOTE, G. D. (1962). The suitability of some plant hosts for the development of the peach–potato aphid, *Myzus persicae* (Sulzer). *Ent. exp. & appl.* **5**, 114–118.

(For summary see No. 16.15)

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7.27 HEATHCOTE, G. D. & GIBBS, A. J. (1962). Virus diseases in British crops of field beans (*Vicia faba* L.). *Plant Path.* **11**, 69–73.

Pea leaf roll, pea enation mosaic and pea mosaic viruses were common in British crops of field beans in 1959, 1960 and 1961, but most plants became infected late in the season. Of the four aphid species (*Acyrthosiphon pisum*, *Aphis fabae*, *Myzus persicae* and *Megoura viciae*) infesting the beans, *A. pisum* seemed to be the most important vector. The yield of beans was decreased by infection by any of the viruses, but more by PLRV than by the other two. Earliest infections decreased yield most; yield was mainly affected by infection decreasing the number of pods per plant.

7.28 HIRST, J. M. & STEDMAN, O. J. (1962). The epidemiology of apple scab (*Venturia inaequalis* (Cke.) Wint.). II. Observations on the liberation of ascospores. *Ann. appl. Biol.* **50**, 525–550.

Some of the variables affecting the liberation of *Venturia inaequalis* ascospores in orchards were studied in the laboratory, either in a wind tunnel of approximately 1 ft square cross-section or in four smaller tunnels where the annual ascospore production from replicated, small, uniform area samples of dead apple leaf could be compared.

Dew releases some ascospores, but very few compared to rain. The equivalent of 0·2 mm of rain applied evenly with an atomiser released very many. Some small daytime releases occurred in dry weather, but they followed wetting at night, either by rain or dew. In orchards 75% of the spores released by brief rains were liberated within 3 hours; for rains of all durations the comparable figure was 6 hours. Despite the part rain plays in release, there were more ascospores on average in the air at the middle of the day than at any other time, a distribution not shared by rain. This discrepancy could not be explained by the individual effects of light, the time elapsed between wettings or by temperature (except when very close to freezing point). Observations of the release when atmospheric turbulence was constant or slight suggested that the smaller liberation at night could result from the interaction between temperature and the time for maturation since the previous wetting.

When wetted at weekly intervals the maturation of ascospores followed an approximately normal distribution, although the peak was often narrow. The distribution could be modified by changing environmental factors, such as temperature and moisture, or the date when the leaves were collected. Tests of these factors were used to formulate a routine laboratory method for comparing the annual ascospore productivity of a standard area of dead leaf. It can be used to assess the ascospore potential of variously treated small plots, or of leaf samples from different varieties and localities. It allows new methods to be introduced for studying ascospore discharge by *Venturia* and other fungi. Although current experimental designs and the high variability of samples restricted its usefulness to distinguishing large differences, such differences are common, and their existence suggests that the control of apple scab could be improved by attacking the overwintering ascospores.

7.29 HIRST, J. M. & STEDMAN, O. J. (1962). The epidemiology of apple scab (*Venturia inaequalis* (Cke.) Wint.). III. The supply of ascospores. *Ann. appl. Biol.* **50**, 551–567.

The prevalence of *Venturia inaequalis* ascospores in orchards was compared both in terms of the number of spores per volume of air (dose) and the number produced per area of dead leaf (productivity). The two parameters often gave divergent estimates, probably because dose depends on total leaf per unit area of ground whereas productivity does not. Differences in the amount of dead

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leaf surviving until bud-burst in different orchards or years were enough to explain the anomalies and suggested that because earthworms often removed over 90% of the fallen leaves by spring, they exercised an important control of ascospore number.

Assessments of fruit surface scabbed, an accepted way of judging scab control, were not related to ascospore productivity the following spring, but estimates on the percentage of all leaves infected at leaf-fall were. Other natural variables, such as the dates when leaves were formed or fell, seemed of minor importance, especially when compared with effects of earthworms or chemicals. Applying dinitro-ortho-cresol to dead leaves in spring decreased the number of ascospores liberated by at least 90%, and there is evidence of a similar effect from broadcast ammonium sulphate. The spring and summer spray programmes were also important. Measurements in several orchards during an 8-year period showed that dose and productivity both declined to less than a hundredth of the highest levels, but in a single wet year productivity in sprayed orchards increased several times and by 40-fold on unsprayed trees. Ways to prevent many ascospores occurring are discussed, together with possible causes of past severe attacks of apple scab at Wisbech.

7.30 KASSANIS, B. (1962). Properties and behaviour of a virus depending for its multiplication on another. *J. gen. Microbiol.* **27**, 477–488.

The Rothamsted culture of tobacco necrosis virus contains two serologically unrelated viruses one of which, called the "satellite virus" (SV), causes no lesions and multiplies detectably only when the other (TNV) is present. It decreases the size of necrotic local lesions formed by TNV. Inocula containing both viruses gave the same, fewer or more lesions than inocula containing only TNV; the results depended on the ratio of the two viruses in the mixed inoculum, on the species and age of the test plants and, particularly, on the temperature at which the plants were kept after the inoculation. The concentration of TNV decreased when SV was also present; the extent of the decrease depended on the ratio of the two viruses in the inoculum and other factors. Inoculation with SV 5 days before inoculation with TNV still decreased lesion size and led to the multiplication of SV. Phenol-disrupted SV affected lesion size only when inoculation with TNV followed within a few hours, but when inoculation with TNV was delayed by up to 2 days SV sometimes multiplied detectably. SV has the smallest particle reported for any plant virus; diameter *c.* 17 mμ and weight equivalent to a molecular weight of about $1{\cdot}9 \times 10^6$, of which 20% is nucleic acid. It is exceptionally stable, retaining infectivity after 17 years at 3° and after heating for 10 minutes at 90°. TNV was much more susceptible than SV to inactivation by heat and by ultra-violet light. The two differed greatly in electrophoretic mobility and were readily separated from mixed preparations by electrophoresis.

7.31 KASSANIS, B. & (SCHWABE, W. W.) (1961). The effect of paracrinkle virus on the growth of King Edward potato at different temperatures and daylengths. *Ann. appl. Biol.* **49**, 616–620.

The growth of King Edward potatoes of a stock freed from paracrinkle virus was slightly but consistently superior to that of an infected stock when grown in controlled environments. Although the leaves of the infected plants showed no evident symptoms, their smaller water content suggested incipient N-deficiency. Changes in daylength and night temperature affected virus-free and infected plants similarly. Long days and warm nights decreased tuber formation, and the larger tuber and total dry weights in short days probably resulted from increased leaf area and decreased stem growth.

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7.32 KLECZKOWSKI, A. (1962). Destruction of antigenicity *in vitro* of human serum albumin and of tobacco mosaic virus by ultra-violet radiation. *Photochem. Photobiol.* **1**, 291–297.

Ultra-violet irradiation first makes human serum albumin unable to precipitate with antibody to the original albumin and then destroys its ability to combine with the antibody. With tobacco mosaic virus both the ability to precipitate and to combine with antibody to the original virus are destroyed simultaneously or nearly so. A rough estimate shows that about 5 joules of radiation energy (at $\lambda = 2537$ Å) must be absorbed by each milligram of human serum albumin or of the protein of the virus to reduce their capacity to combine with antibodies to half. The structure of the two antigens is very considerably altered before their specific combining capacity is destroyed, which contrasts with relatively slight alterations in the structure of typical enzymes or antibodies when their specific activities are destroyed or in the virus when its infectivity is destroyed.

7.33 KLECZKOWSKI, A. & (GOLD, A. H.) (1962). Effects of ultra-violet radiation on antigenicity of horse serum albumin: formation of new determinants. *Photochem. Photobiol.* **1**, 299–304.

Structural alterations in horse-serum albumin caused by ultra-violet radiation resulted in disappearance of the original determinants and in formation of new determinants. There was, however, enough similarity between the original and the new determinants for antibodies produced by the new determinants to show a weak affinity to the non-irradiated albumin. Only weak antisera were produced by injecting rabbits with extensively irradiated albumin.

7.34 LACEY, M. E. (1962). The summer air-spora of two contrasting adjacent rural sites. *J. gen. Microbiol.* **29**, 485–501.

The air in a valley near a stream and in an exposed site on a small hill at Silwood Park, near Ascot, Berkshire, was sampled from 14 May to 25 September 1958 at half a meter above the ground by a Hirst automatic volumetric spore trap. Seasonal periodicities of 26 categories of fungus spores and 7 categories of pollen grains are given as 6-day running means of the daily average number of spores per cubic meter of air. Estimated hourly concentrations of spores for 6 consecutive days are given for three fungus spores types and two pollens. The diurnal periodicity is given for these groups. There were 2·6 times more spores at site S near the stream than at the exposed site M. There were 4·9 times more spores of ascomycetes at S than at M, 3 times as many spores of basidiomycetes but only 1·4 times as many from fungi imperfecti. The proportion of the different types of spores at the two sites differed; 14% of spores at S were from ascomycetes, 7% at M; 17·5% of those at S were from fungi imperfecti and 32% of those at M. Tree pollen grains were equal in number at both sites, but there was 2·8 times more grass pollen and 6·5 times more weed pollen at S than at M. Urtica pollen was 8·1 times as common at S and made up 55% of the total pollen in that area, but only 24% of the total at M, mainly because of the local abundance of nettle plants. The results suggest that the ecology of an area has a major influence on its air-spora through local flora and micro-climate.

7.35 LACEY, M. E. & GREGORY, P. H. (1962). Occurrence in Britain of the fungus causing facial eczema in sheep. *Nature, Lond.* **193**, 85.

Pithomyces chartarum (Berk. and Curt.) M. B. Ellis (syn. *Sporidesmium bakeri* Sydow.), the saprophytic mould whose toxin causes facial eczema of sheep in New Zealand, was first seen in this country on a Hirst trap slide from the

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Imperial College Field Station, near Ascot, Berks, for 7 July 1958. In September 1961 spores were found in the air in several areas in Surrey and Berkshire. The fungus was subsequently found on *Holcus lanatus* debris near Virginia Water, Surrey.

7.36 LAPWOOD, D. H. (1963). Potato haulm resistance to *Phytophthora infestans*. IV. Laboratory and field estimates compared, and further field analyses. *Ann. appl. Biol.* **51**, 17–28.

Haulm susceptibility to *Phytophthora infestans* (Mont.) de Bary of 14 widely differing potato varieties was compared in laboratory and field tests with the maincrop variety Majestic as a standard. These two tests gave similar results, except that the early varieties Viola and Arran Pilot were more resistant in the laboratory than in the field.

The sequence of infection within the crop canopy was the same in susceptible and resistant varieties, starting first mainly on the lowest leaves on the stem, then the middle and finally the uppermost. This sequence was lost when haulm became prostrate. Varieties differed in the rate that infection spread and leaves were destroyed, some being attacked more rapidly, and others more slowly, than Majestic.

In the field the fungus spored on different varieties as in the laboratory test; the annulus was wide and sporulation intense on susceptible varieties, but narrow and sparse on resistant ones.

7.37 TINLINE, R. D. (1961). *Cochliobolus sativus*. IV. Drug-resistant, color, and nutritionally exacting mutants. *Canad. J. Bot.* **39**, 1695–1704.

Auxotrophic mutants of *Cochliobolus sativus* were obtained from survivors of ultra-violet radiation by a modified total-isolation technique. Five or six hyphal tip isolations made from each survivor were tested for nutritional deficiencies. Although 0·48% of the survivors yielded auxotrophs, only about one-third of the hyphal tip isolations from these surviviors were auxotrophic. Apparently, mutation in a multinucleate propagule resulted in a heterokaryotic culture, and only some of the isolations from a culture were homokaryotic for the mutation. Some of the mutants were morphologically distinct from their parent and one, a methionineless strain, had white spores. Results indicated that recurrent requirements for growth occurred at different mutational sites.

A strain resistant to the antibiotic anisomycin appeared as a spontaneous mutation. This strain grew at 1,500 and its spores germinated at 1,750 ppm; wild-type isolates grew only at 75, and their spores germinated at 100 ppm of the drug. The resistant mutant was pathogenic to wheat seedlings.

7.38 WATSON, M. A. (1962). Yellow-net virus of sugar beet. 1. Transmission and some properties. *Ann. appl. Biol.* **50**, 451–460.

A virus found in sugar beet in England causes similar symptoms to the Californian virus called yellow-net (YNV) by Sylvester (1948). It persists in the feeding vectors for at least 7 days. The minimum feeding time needed for aphids to acquire virus from infected leaves was 6 hours and the minimum needed to acquire and transmit was 12 hours, but ability to transmit was greatly increased by increasing feeding time up to 2 days on infected and 24 hours on healthy plants. These properties agree with those of the American virus. Experiments using different aphid numbers feeding for constant times suggested that susceptibility of sugar beet to infection varies, and this may account for some of the delay in infecting healthy plants.

YNV was accompanied in beet by a second virus, yellow-net mild yellows (YNMYV). YNMYV did not infect *Nicotiana clevelandi* Gray or *N. bidlovia*,

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which are susceptible to YNV, but from which YNV could not be recovered by aphids. Neither virus is transmissible by inoculation with sap from infected plants. It is suggested that YNMYV is a "carrier" virus, without which YNV cannot be transmitted. Possibly it combines with YNV to form an aphid-transmissible combination, but it may merely help YNV to invade sugar beet. YNMYV causes similar symptoms and has similar properties and host range to other viruses that cause mild yellowing diseases of sugar beet, including avirulent strains of beet yellows virus (BYV), Irish mild yellows (IMSV) and "41 yellows" (41YV). No such virus has been reported associated with YNV in America, and possibly it is peculiar to the British isolate.

Nematology Department

Books

8.1 Goodey, J. B. (1963). *Laboratory methods for work with plant and soil nematodes.* (*Tech. Bull. Minist. Agric., Lond.* No. 2), 4th edition of bulletin originally by T. Goodey, 1949. London: H.M. Stationery Office. (In the press.)

8.2 Goodey, T. (1963). *Soil and freshwater nematodes.* 2nd edition revised by J. B. Goodey. London: Methuen, 544 pp.

In this revised edition the class Nematoda is divided into ten Orders covering the nematodes found in soil and freshwater. The binary division into Phasmidia and Aphasmidia, or Secernentea and Adenophora, is discarded. A short section on techniques and the general structure of a nematode is followed by a detailed classification down to genera. For each genus a representative species is described and figured (often the type species) and a complete list of other species in the genus and their synonyms is given.

Theses

8.3 Blake, C. D. (1962). Some aspects in the host parasite relationships of the stem nematode, *Ditylenchus dipsaci* in oats. Ph.D. Thesis, University of London.

8.4 Webster, J. M. (1962). Studies on the biology of the narcissus strain of *Ditylenchus dipsaci* (Nematoda) in the host plant and in the soil. Ph.D. Thesis, University of London.

General Papers

8.5 Doncaster, C. C. (1962). Predators of soil nematodes (Film). *Parasitology* **52**, 19P Abstr.

8.6 Goodey, J. B. (1962). The preparation of figures for illustration in Nematologica. *Nematologica*, **8**, 80–83.

8.7 Jones, F. G. W. (1962). Plant nematodes. *Sci. Progr.* **50**, 550–567.

8.8 Peachey, J. E. (1962). The chemical control of plant-parasitic nematodes by soil fumigation. *N.A.A.S. quart. Rev.* No 57, 34–45.

8.9 Peachey, J. E. (1963). Chemical soil sterilisation. *Smallholder* **108**, (2732), 24.26.

8.10 Peachey, J. E. (1963). How chemical soil sterilisation can help crops. *Smallholder* **108**, (2733), 25.

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8.11 WALLACE, H. R. (1962). The future of nematode ecology. *J. Parasit.* **48**, 846–849.

8.12 WEBSTER, J. M. (1962). The spread of the stem and bulb eelworm (*Ditylenchus dipsaci*) population in narcissus. *Parasitology* **52**, 12–13P. Abstr.

RESEARCH PAPERS

8.13 BLAKE, C. D. (1962). The etiology of tulip-root disease in susceptible and resistant varieties of oat infested by the stem nematode *Ditylenchus dipsaci* (Kühn) Filipjev. I. Invasion of the host and reproduction by the nematode. *Ann. appl. Biol.* **50**, 703–712.

The number of pre-adult larvae of *Ditylenchus dipsaci* that invaded seedlings of the oat variety Sun II growing in sand was linearly related to the number of larvae in the inoculum. In seedlings growing on pads invasion rates were higher but were limited to about 200 nematodes per plant. The respective numbers of larvae invading the susceptible varieties Sun II and Powys and the resistant varieties Manod and Pennant were not significantly different after 3 days. Reproduction occurred in the susceptible varieties, but after 28 days the number of nematodes per plant in the susceptible varieties was about double that in the resistant ones. When the resistant variety Manod was infested at germination 33% of the seedlings were killed after 14 days compared with 45% of the susceptible variety Sun II. More larvae invaded the pseudostems than the root systems and reproduction occurred only in the pseudostems. Oat and lucerne seedlings were invaded by larvae of both the lucerne and oat races of *D. dipsaci*, but only in the compatible host did reproduction occur.

A method for classifying plants attacked by stem nematodes is proposed based on the reaction of the tissues and the multiplication of the nematode within them.

8.14 BLAKE, C. D. (1962). The etiology of tulip-root disease in susceptible and resistant varieties of oats infested by the stem nematode *Ditylenchus dipsaci* (Kühn) Filipjev. II. Histopathology of tulip-root and development of the nematode. *Ann. appl. Biol.* **50**, 713–722.

Ditylenchus dipsaci caused cells to enlarge and separate in tissues of the susceptible oat variety Sun II. Cytoplasm was withdrawn from the cells, the walls of which collapsed to form a cavity around the nematodes. In the resistant variety Manod separation and hypertrophy were slight, but cytoplasm was withdrawn and cavities formed similar to those in Sun II; hyperplasia or necrosis was not seen.

The body and gonads in nematodes from Manod plants were shorter than from Sun II, but the de Man ratios and the ratio of males to females were the same. Fourth-stage larvae matured to adults more slowly in Manod seedlings. Nematodes grew by a series of steps caused by alternating periods of slow growth before a moult and rapid growth afterwards. In Manod *D. dipsaci* grew more slowly, but the form of the growth curve was as in Sun II. Gonads lengthened rapidly and continuously during the late fourth larval and early adult stages, and especially during the period before the fourth moult when body length stopped increasing.

8.15 BLAKE, C. D. (1962). Some observations on the orientation of *Ditylenchus dipsaci* and invasion of oat seedlings. *Nematologica* **8**, 177–192.

In sand fractions with particles of diameter larger than 150 μ, the speed *Ditylenchus dipsaci* larvae migrated was closely correlated with the number that

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invaded oat seedlings within 3 days of inoculation. Migration was fastest and invasion rates highest at the flex point of the moisture characteristic of each sand when the pores were draining.

In either sand or aseptic conditions on agar, larvae accumulated around seedlings even when the larvae were separated from the seedlings by dialysis membranes. In the rhizosphere larvae appeared to orientate along a concentration gradient of secretions from the plant, whereas elsewhere they moved at random. Not all the larvae that arrived at a root stayed there. Accumulation depended on fewer leaving than arriving and also on the moisture content of the sand. Larvae belonging to the oat, red clover, lucerne and daffodil races were attracted to oats, and most accumulated at the "root-stem junction" of oat seedlings.

8.16 CORBETT, D. C. M. (1962). The occurrence of *Criconemoides macrodorum* Taylor, 1936 in Central Africa. *Nematologica* **8**, 176.

8.17 DONCASTER, C. C. (1962). A counting dish for nematodes. *Nematologica* **7**, 258.

8.18 DONCASTER, C. C. (1962). Sealing microscopical water mounts with soft wax. *Nematologica* **7**, 334–336.

8.19 DONCASTER, C. C. (1962). Nematode feeding mechanisms. 1. Observations on *Rhabditis* and *Pelodera*. *Nematologica* **8**, 313–320.

Oesophageal structure of *Rhabditis* (*Cephaloboides*) *oxycerca* and *Pelodera* (*Cruznema*) *lambdiensis* was studied from sections and whole mounts, and ciné-films were used to study the feeding mechanism. Water, with suspended food particles small enough to pass through the stoma, is drawn as far as the fore end of the isthmus by sudden dilation of the pro-corpus and median bulb. Closure of the lumen in these regions expels excess water, and the accumulation of food is passed steadily backward by a wave of contraction of the radial muscles of the isthmus. Particles are drawn between the posterior bulb flaps by dilation of the haustrulum and are passed to the intestine by closure of the haustrulum and by dilation, followed by closure of the oesophago-intestinal canal. The bulb flaps may contribute to the closure of the inlet valve to the haustrulum, but they also compress food particles when they invert, and some particles are thus ruptured.

8.20 FENWICK, D. W. (1961). Estimation of field populations of cyst-forming nematodes of the genus *Heterodera*. *J. Helminth.*, R. T. Leiper Suppl. 63–76.

Fields differ greatly in density of infection with cyst-forming nematodes and also in the uniformity of distribution. Composite samples from fields should be made up of 25–100 borings: the increase in precision by taking more than this is rarely justified. The accuracy of an estimation based on samples taken in this manner varies and cannot be forecast beforehand. If a predetermined level of accuracy is desired preliminary samples should be taken to estimate heterogeneity and the final sampling should be based on this preliminary estimate.

8.21 FRANKLIN, M. T. (1962). Preparation of posterior cuticular patterns of *Meloidogyne* spp. for identification. *Nematologica* **7**, 336–337.

For critical examination of the posterior cuticular patterns of *Meloidogyne* species infested roots can be processed in several ways. Treatments that would grossly distort most nematodes can be used to prepare specimens for species determination.

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8.22 FRANKLIN, M. T. & HOOPER, D. J. (1962). *Bursaphelenchus fungivorus* n. sp. (Nematoda: Aphelenchoidea) from rotting Gardenia buds infected with *Botrytis cinerea* Pers. ex Fr. *Nematologica* **8**, 136–142.

Bursaphelenchus fungivorus n. sp. is described and figured. It readily reproduces on cultures of *Botrytis cinerea* from rotting Gardenia buds in which it was found. Its larval stages and rate of reproduction are described.

8.23 FRANKLIN, M. T. & SIDDIQI, M. R. (1963). *Aphelenchoides trivialis* n. sp. from South India. *Nematologica* **9**. (In the press.)

Found in soil around coffee roots, this new species differs from other saprophagous aphelenchs in the relative body dimensions and in having a long, reflexed ovary. Males not found.

8.24 GOODEY, J. B. (1962). *Tylenchus* (*Cephalenchus*) *megacephalus* n. sbg., n. sp. *Nematologica* **7**, 331–333.

Tylenchus (*Cephalenchus*) *megacephalus* has an offset, rounded head, coarse annulation, six incisures and no lateral, vulval flaps.

8.25 GOODEY, J. B. & HOOPER, D. J. (1962). Observations on the attack by *Ditylenchus dipsaci* on varieties of oats. *Nematologica* **8**, 33–38.

Biotypes of the oat race of *D. dipsaci* may occur in Britain. Resistant Milford oat seedlings were invaded, but no typical tulip-root symptoms developed, although some seedlings were killed. Resistance increases with age of the host. About 12% of 145 oats tested were resistant and another 8% partially so. The factors for resistance can possibly be traced back to *Avena byzantina*.

8.26 HARRISON, B. D. & HOOPER, D. J. (1963). Longevity of *Longidorus elongatus* (de Man, 1876) and other nematodes in soil kept in polythene bags. *Nematologica* **9**. (In the press.)

Adult *L. elongatus* survived better than larvae when moist soil was kept in bags without plants for 29 months at about 18°C. Most survivors were able to feed on cucumber roots. Other surviving nematodes included *Pratylenchus crenatus* and *Tylenchorhynchus dubius*.

8.27 HESLING, J. J. & PEACHEY, J. E. (1963). Experiments on the control of chrysanthemum eelworm by physical and chemical treatment of chrysanthemum stools. *Plant Path.* **12**. (In the press.)

Chemical and physical treatments were applied to chrysanthemum stools to control *Aphelenchoides ritzemabosi*. Hot-water, parathion and iodine in potassium iodide were the most effective, but this formulation of iodine was phytotoxic, and treated stools produced fewer cuttings than usual. Cuttings taken from treated stools grew normally. Thorough washing of stools did not consistently control the infestation, suggesting that success depends on killing eelworms within plant tissue.

8.28 HOOPER, D. J. (1962). Three new species of *Trichodorus* (Nematoda: Dorylaimoidea) and observations on *T. minor* Colbran, 1956. *Nematologica* **7**, 273–280.

Trichodorus cylindricus n. sp., ♀ & ♂, and *T. teres* n. sp., ♀ are described from light sandy English soils. *T. borneoensis* n. sp., ♀ & ♂, was found associated with roots of Manila hemp from North Borneo. The original description of *T. minor* Colbran 1956 is amplified, using specimens associated with sugar-cane roots from Queensland, Australia.

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8.29 JONES, F. G. W. (1962). A note on Granek's ratio for the separation of *Heterodera rostochiensis* W. and *H. tabacum* L & L. *Nematologica* **7**, 256–258.

Although Granek's ratio would rarely fail to distinguish between Connecticut tobacco cysts and Long Island potato cysts, it would often fail to differentiate between tobacco cysts and potato cysts from Britain.

8.30 JONES, F. G. W. & GANDER, M. C. (1962). A bioassay for *Heterodera* spp. without counting cysts or larvae. *Nematologica* **8**, 39–50.

Cyst batches of approximately equal size for use in bioassays can be set up with a simple pipette, and the larvae that hatch from them can be assessed by absorptiometry, which saves the time and tedium of counting both cysts and larvae. In an experiment on the use of charcoal to recover the hatching factor from potato-root diffusate the results of bioassays by this method agreed well with those based on counts.

8.31 JONES, F. G. W. & NIRULA, K. K. (1963). Hatching tests and counts of primary galls in assessment of nematicides against *Meloidogyne* spp. *Plant Path.* **12**. (In the press.)

Hatch of *Meloidogyne* eggs was inhibited by 0·1–1*M* sucrose and urea and by methylisothiocyanate at 10–100 ppm. After transfer to water there was no hatch after 1*M*-urea, a small hatch after 10 ppm methylisothiocyanate and a larger one after 1*M*-sucrose. Some eggs seemed alive after 21 days in 100 ppm methylisothiocyanate.

Counts of galls on root systems of tomato plants were unaffected by root size and followed closely the number of larvae in the roots, except where the inoculum was large and produced multiple galls. The proportion of larvae established after 7 weeks fell from 35% at the smallest inoculum to 2% at the largest.

Both tests are satisfactory for nematicide testing, but may underestimate mortality when hatching is delayed and the kill not immediate. The hatching test detects powerful inhibitors within 4–10 days.

8.32 JONES, F. G. W. & PAWELSKA, K. (1963). The behaviour of populations of potato-root eelworm (*Heterodera rostochiensis* Woll.) towards some resistant tuberous and other solanums. *Ann. appl. Biol.* **51**, 269–276.

Forty-seven British populations of potato-root eelworm (*Heterodera rostochiensis*) were tested for ability to form cysts on plants with resistance derived from *Solanum tuberosum* spp. *andigena*, *S. multidissectum*, *S. vernei*, *S. sanctae-rosae*. *S. famatinae* and *S.* × *juzepczukii* and on *S. nigrum*, *S. sarachoides* and *Nicotiana* spp.

The potato variety Arran Banner was used as the standard susceptible host, and the number of cysts formed on the resistant plants in pot tests was expressed as a percentage of those formed on Arran Banner or assessed visually from the cysts observed on the outside root mat. Cyst production on *andigena* hybrids ranged from less than 1% of those on Arran Banner to slightly over 100%. About half of the populations produced 10% or less, and populations of this type against which *andigena* resistance would be effective were especially common in South-East England and Northern Ireland. Cyst production on *famatinae* hybrids, a race of *S. nigrum* from East Germany, *S. miniatum* and *S. sarachoides*, resembled that on *andigena* hybrids. Cyst production on *multidissectum* hybrids varied less, and only a few populations produced less than 10% and none less than 3% of the cysts on Arran Banner. *S. vernei* was highly resistant to all but about 5% of populations, and a race of *S. nigrum* from Rothamsted was resistant to all tested.

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In selection experiments the proportion of females able to complete development increased when *andigena* hybrids, *S. vernei* or *S. nigrum* were grown repeatedly in the same inoculum. Increase on *S. vernei* was slow, the pattern of increase on *andigena* suggested recessive inheritance, but this could not be confirmed, and increase on *S. nigrum* was more rapid, suggesting different genetic mechanisms for resistance and resistance-breaking in the three types of plant.

8.33 LIMA, M. B. & SIDDIQI, M. R. (1963). *Boleodorus volutus* n. sp. (Nematoda; Nothotylenchinae) found in the soil about grass roots in England. *Nematologica* **9**, 19–23.

Boleodorus volutus n. sp. found associated with grass roots in England is described and figured. *B. volutus* differs from other species of the genus by becoming spiral when dead, and by possessing wide oblique amphid apertures, a shorter stylet, a vulva located more posteriorly and a tail with rounded terminus. Doubt is expressed on the inclusion of *B. clavicaudatus* Thorne, 1941 in the genus.

8.34 PEACHEY, J. E. (COLLINGWOOD, C. A.) & RAO, G. N. (1963). Control of potato-root eelworm in a glasshouse soil with a formulation of methyl isothiocyanate. *Plant Path.* **12.** (In the press.)

A formulation of 20% methyl isothiocyanate in xylol ("Trapex", "Trapexide") was applied at 125 ml/m² to plots of glasshouse soil heavily infested with potato-root eelworm 34 days before planting with tomatoes. "Live eggs", hatched larvae, larvae in roots and larvae in soil after treatment, and "live eggs" after harvest were counted. Counts of "live eggs" underestimated kill, but other assays agreed with each other. Injection gave a 93–99% kill and was superior to surface sprinkling of the sterilant and sealing with waterproof paper, which gave a kill of 82–85%. Plant height and tomato fruit production were increased by treatment, especially on injected plots, where 24 tons/acre more fruit was produced than from untreated plots. None of the treatments injured the tomato plants.

8.35 PEACHEY, J. E., GANDER, M. C. & (Members of the National Agricultural Advisory Service) (1963). Chemical control of potato-root eelworm in glasshouses: experiments in 1961. *Exp. Hort.* No. 9. (In the press.)

The standardised evaluation of four soil sterilants applied to replicated randomised plots in eight glasshouses showed that except in a Lancashire moss soil, dazomet (85% dust formulation of dimethyl tetrahydrothiadiazine thione) at ¾ lb/100 sq ft controlled potato-root eelworm better than MIC (20% methyl isothiocyanate in xylene) at 2 pints/100 sq ft, metham-sodium (32% sodium methyl dithiocarbamate) at 2 pints/100 sq ft or "D-D" (dichloropropane-dichloropropene) at 1 lb/100 sq ft. Dazomet was mixed with the soil, whereas the other chemicals were injected. Hatching tests and counts of larvae in roots or cysts on the root mat of the potato plants grown in soil samples agreed in their estimate of the best treatment.

Eelworm attack was correlated with root weights of the pot-grown indicator plants used in the root invasion assay, but tomato crop responses following treatment were not specifically related to eelworm control because of variations in the biocidal activity of the chemicals, cultural practices and incidence of disease.

8.36 PEACHEY, J. E. & HOOPER, D. J. (1963). Chemical treatment of quarantined banana stocks infested with plant parasitic nematodes. *Plant Path.* **12.** (In the press.)

Helicotylenchus dihystera, *Radopholus similis* and *Meloidogyne* spp. were found infesting quarantined banana stocks held at the Royal Botanic Gardens, Kew,

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England. Dipping peeled "sets" in nematicidal chemicals and applying dibromochloropropane ("Nemagon") at intervals to the growing plants in pots checked the infestations and promoted healthy root growth.

8.37 PEACHEY, J. E., RAO, G. N. & CHAPMAN, M. R. (1963) Field tests on experimental and commercial soil sterilants against the potato-root eelworm, *Heterodera rostochiensis* Woll. *Ann. appl. Biol.*, **51**. (In the press.)

Five experiments were done on sandy-loam containing 12% clay. Methyl bromide, "D-D", metham-sodium, dazomet, methyl isothiocyanate and several experimental compounds were applied at different doses and in different ways. Assays of live eggs, hatched larvae, larvae in roots or cysts formed on the root-mat of potato indicator plants and counts of nematodes free in the soil selected the same treatment as the most effective.

8.38 PEACHEY, J. E. & (WINSLOW, R. D.) (1962). Effects of soil treatments on populations of soil nematodes and on carrot crops grown for two years after treatment. *Nematologica* **8**, 75–79.

Sodium methyl dithiocarbamate, methyl bromide, methyl bromide plus chloropicrin, dimethyl tetrahydrothiadiazine thione, dichloropropane-dichloropropene and ethylene dibromide killed soil nematodes including *Pratylenchus* and other non-cyst forming tylenchids in light sandy soil at the Royal Horticultural Society's Gardens at Wisley, Surrey, England. Improved yield and quality of carrots grown on land treated with methyl bromide or methyl bromide plus chloropicrin were attributed to the partial sterilisation effect of soil treatment and not to the elimination of the nematodes.

8.39 PETERS, B. G. (1961). *Heterodera rostochiensis* population density in relation to potato growth. *J. Helminth.*, R. T. Leiper Suppl., 141–150.

By exposing potato plants in pots to a graded series of inocula of cysts of *Heterodera rostochiensis* effects on the plant host were studied in terms of growth of shoots and tubers. Large inocula lessen both severely, but plants grown in a very small inoculum were larger than uninoculated controls.

The smallest inocula gave the largest multiplication, but the greatest population came from a moderate inoculum. Thus, the kind of inoculum that would stimulate crop yields would also lead to a large eelworm population; largest potato yields were associated with an eelworm multiplication factor of about ten-fold.

8.40 SHEPHERD, A. M. (1962). Larval emergence in pea root eelworm, *Heterodera göttingiana* Liebscher. *Nematologica* **7**, 14–15. Abstr.

All attempts to hatch larvae from cysts of *H. göttingiana in vitro* failed. A study of hatching under a host crop, a non-host crop and in fallow soil in the field showed that *H. göttingiana* behaved like *H. rostochiensis*. More larvae of both species emerged under the host crop than under the non-host or in fallow soil, showing that host roots stimulated hatch.

8.41 SHEPHERD, A. M. (1962). New blue R, a stain that differentiates between living and dead nematodes. *Nematologica* **8**, 201–208.

New blue R stains the body contents of dead Tylenchida from pale mauve to deep purple, but not living nematodes. The dye is water soluble and non-toxic; the method is simple and requires no specialised apparatus. Dead individuals of *Meloidogyne*, *Ditylenchus*, *Aphelenchoides*, *Aphelenchus* and *Anguina* stain after 1–24 hours in 0·05% new blue R. The simplest method for *Heterodera* is to stain cysts for a week and then to release the eggs in water. If the egg suspension is

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left to stand for a few hours the egg-shells then lose the stain. Stained and unstained larvae inside the eggs can then be counted using a magnification of about × 50. With all these genera any nematode which has taken up the stain, either partially or completely, may be considered to be either dead or dying. Tests with new blue R have shown it to be reliable and less subjective than previous staining methods.

8.42 SHEPHERD, A. M. (1962). Dyes as artificial hatching agents for beet eelworm, *Heterodera schachtii* Schm. *Nature, Lond.* **196**, 391–392.

Tests with 70 dyes from 16 dye-groups showed large differences in their ability to affect hatching of *H. schachtii*. Solutions of several dyes give hatches as great as that from a standard beetroot diffusate; others stimulate hatch less but give a significantly greater hatch than water, and many are inactive. Hydrophilic radicals attached to the benzene nucleus seem to lessen activity. These artificial hatching agents appear to be active at similar concentrations to the natural hatching factor for *H. rostochiensis*.

8.43 SIDDIQI, M. R. (1962). *Longidorus tarjani* n. sp. found around oak roots in Florida. *Nematologica* **8**, 152–156.

Longidorus tarjani n. sp. collected around oak roots in Florida has a knob-like head, a sheath-like spear guide ring located much anteriorly, a very long spear (174–187 μ) and a conoid-rounded tail about one anal-body-width long.

8.44 SIDDIQI, M. R. (1963). *Trichodorus* spp. (Nematoda: Trichodoridae) from Tunisia and Nicaragua. *Nematologica* **9**, 69–75.

Trichodorus tunisiensis n. sp. found around roots of *Sesbania* sp. in Teboulba, Tunisia, has a distinct ventral overlap of the oesophageal base and intestine. It is close to *T. teres* Hooper, 1962, differing in the shape and size of vaginal sclerotisation, presence of spermathecae and shape of tail end. Males and females of *T. nanus* and *T. minor* have been found in Tunisia and Nicaragua respectively.

8.45 SIDDIQI, M. R. (1962). *Trichodorus pakistanensis* n. sp. associated with mulberry trees in Hazara District, with observations on *T. porosus* Allen 1957, *T. minor* Colbran 1956, and *T. mirzai* Siddiqi 1960, from India. *Nematologica* **8**, 193–200.

Many *Trichodorus pakistanensis* n. sp. were found around mulberry roots in Haripur and Abbottabad (Hazara District). It is characterised by a long body (about 1 mm), long buccal spear (39–48 μ) and by the male having three ventromedian oesophageal papillae, of which one is located behind the excretory pore. *T. porosus* and *T. minor* were found for the first time in India around pear and potato roots respectively. *T. minor* was also later found around pear and sugarcane roots. *T. bucrius* Lordello & Zamith, 1958, is considered a synonym of *T. porosus* Allen, 1957. *T. mirzai* also occurs around sugar-cane roots in south India.

8.46 SIDDIQI, M. R., HOOPER, D. J. & (KHAN, E. U.) (1963). A new nematode genus *Paralongidorus* (Nematoda: Dorylaimoidea) with descriptions of two new species and observations on *Paralongidorus citri* (Siddiqi, 1959) n. comb. *Nematologica* **9**, 7–14.

Two new species are described, one from India the other from Australia and India, which have a stylet and guide ring similar to *Longidorus* Micoltezky, 1922, but the amphids are funnel to stirrup-shaped with wide slit-like apertures resembling those of *Xiphinema* Cobb, 1913. *Paralongidorus* n. g. is proposed for these and *Longidorus citri* (Siddiqi, 1959) Thorne, 1961 is included in this genus.

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The type species *P. sali* n. sp. has conspicuous amphid apertures, funnel-shaped amphid pouches in lateral view, a narrow lip region continuous with the body contour and a short round tail. *P. sacchari* n. sp. is larger than *P. sali*, its amphid apertures extend almost across the head and the pouches are stirrup shaped; the tail is dorsally convex, roundly conoid about half an anal-body-width long. A hemizonid has been seen in both species, the first report of this structure in the Longidorinae. The body of one female of *P. sali* was filled with "spores" probably of a sporozoan.

8.47 SIDDIQI, M. R. & (SOUTHEY, J. F.) (1962). *Criconema palmatum* n. sp. (Nematoda: Criconematidae) from North Devon, England. *Nematologica* **8**, 221–224.

Criconema palmatum was found in soil around strawberry roots at Combe Martin, Devon. It is remarkable in having eight scale-like, palmate outgrowths of each body annule, bearing three to six spines. These outgrowths alternate more or less regularly on successive annules. There are 50–57 annules on the body, the excretory pore is on the nineteenth annule, the spear is 78–84 μ long and the vulva on the seventh annule from the hind end.

8.48 WALLACE, H. R. & GREET, D. N. (1963). Observations on the taxonomy and biology of *Tylenchorhynchus macrurus* (Goodey, 1932) Filipjev, 1936 and *Tylenchorhynchus icarus* n. sp. *Parasitology*. (In the press.)

The large and small forms of *Tylenchorhynchus macrurus* are distinguished as *T. icarus* n. sp. and *T. macrurus* respectively. The oxygen consumption of both species is similar when assessed in terms of body surface area. Soil samples in the field indicated that: (*a*) greatest concentrations of *T. icarus* occurred at about 5 cm depth; (*b*) few occurred below 24 cm; and (*c*) numbers in the top 5 cm were correlated with rainfall. *T. icarus* migrates to the wet end of a moisture gradient, has maximum mobility in soil at about field capacity and at 20° and survives osmotic pressures of 22·4 atmospheres in 1*M*-urea for 4 days. Oxygen consumption increased with increasing osmotic pressure, but in 1*M*-urea there was a decline which was even more pronounced in 2*M*-urea. Thirty-five per cent of a population of *T. icarus* survived for 32 weeks in soil without plants. In damp sand at 10° oxygen consumption of the nematodes remained steady for 16 weeks, but by 32 weeks it had decreased, and after 48 weeks the nematodes were dead.

8.49 WEBSTER, J. M. (1962). The quantitative extraction of *Ditylenchus dipsaci* (Kühn) from plant tissues by a modified Seinhorst mistifier. *Nematologica* **8**, 245–251.

Experiments showed that the eelworm loss from the collecting tray of the modified Seinhorst mistifier increased with time and that the eelworms escaped mainly in the surface currents. Eelworms were successfully extracted from sliced narcissus bulbs and from chopped, fresh and dried narcissus leaves. The particle size of the chopped leaves was not critical. Extraction for 48 hours recovered at least 85% of the eelworms and there was a low inter-replicate variability.

Insecticides and Fungicides Department

GENERAL PAPERS

9.1 BARDNER, R. (1962). Some factors affecting the toxicity of systemic insecticidal seed dressings. *XI. Internationaler Kongress für Entomologie, Wien* (1960), **II**, 558–563.

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9.2 BARDNER, R. (1962). Results of experiments with systemic insecticidal seed dressings. *Proc. Brit. Insect. Fung. Conf. Brighton* (1961), 61–66.

9.3 SAWICKI, R. M. (1962). Action synergétique du Safroxan et du pipéronyl butoxyde avec les pyréthrines. *Feuilles d'informations du Comité français pour l'étude des Applications des Pyréthrines* No. 7, 8–19.

RESEARCH PAPERS

9.4 BARDNER, R., LORD, K. A. & SOLLY, S. R. B. (1963). A cholinesterase inhibition method of determining the distribution of organophosphorus insecticides in soils. *Chem. & Ind.* 123–124.

The distribution of organophosphorus insecticides in soil profiles can be determined by allowing the insecticide to diffuse into a thin film of gelatine supported on a glass plate. A preparation of insect esterases on filter-paper is applied to the gelatine surface and allowed to react with the insecticide, which inhibits esterases. A chromogenic substrate (indoxyl acetate) is then applied to the paper and is converted to indigo, where the enzyme is not inhibited. The method was used to detect the spread of phorate and dimethoate from treated seeds and detected as little as 1 part in 10,000 of the parent compound.

9.5 (HARRIES, J. M.) & POTTER, C. (1962). Change of flavour of potatoes grown on different soils treated with insecticides. *Exp. Husbandry* No. 8, 23–29.

With potatoes as a test crop to assess change of flavour after using soil insecticides, the results were:

1. Aldrin at the rate of 4 lb/acre caused no change in flavour on any of the three soil types or with any of the crop rotations.
2. Dieldrin at the rate of 4 lb/acre only affected flavour on the light sandy loam. The change, though deleterious, was slight. No effect of crop rotation was detected.
3. Lindane caused a change of flavour regarded as deleterious with both rates of application (¾ lb/acre and 1½ lb/acre) on all the soil types. The persistence and intensity was influenced by the soil type, and was greatest in light sandy loam and least in heavy clay loam. There was some effect of crop rotation, and the taint was slightly lessened by growing cereals before potatoes.

9.6 LAST, F. T. (1962). Analysis of the effects of *Erysiphe graminis* DC. on the growth of barley. *Ann. Bot., Lond. N.S.* **26**, 279–289.

Three barley varieties, Plumage Archer, Proctor, and Haisa II, inoculated soon after emergence with *Erysiphe graminis*, the cause of powdery mildew, grew and yielded less than barley repeatedly sprayed with lime sulphur.

Size of roots was affected more than tops, so the dry-weight ratio of root/total plant was decreased. The smaller tops reflected fewer shoots, which, later, were also smaller than on sprayed plants.

Decreases in leaf area paralleled decreases in dry weight of tops. Powdery mildew affected the balance between the absorbing system and the assimilating and transpiring system by decreasing the average dry weight of roots per unit leaf area from 0·92 to 0·63 mg/cm². Disease also decreased the efficiency of unit leaf area; from 12 to 68 days after inoculation the mean net assimilation rate was 226·6 in sprayed controls and 166·0 ± 8·6 mg/dm²/week in the inoculated series.

Powdery mildew retarded stem elongation and possibly caused stunting. Fewer and smaller ears were produced by inoculated than by sprayed plants.

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9.7 LAST, F. T. (1962). Effects of nutrition on the incidence of barley powdery mildew. *Plant Path.* **11**, 133–135.

Applying N and P to field crops of spring-sown barley significantly increased grain yields. N nearly doubled the incidence of powdery mildew, whereas P halved it. Adding K affected neither yield nor powdery mildew.

9.8 SAWICKI, R. M. (1962). Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. III. Knock-down and recovery of flies treated with pyrethrum extract with and without piperonyl butoxide. *J. Sci. Fd Agric.* **13**, 283–292.

The influence of concentration and of time after treatment on knock-down and recovery from the action of pyrethrum extract alone and with piperonyl butoxide at 2 : 1 and 1 : 5 w/w, was studied on house flies (*Musca domestica* L.) by a measured-drop method. The unanaesthetised flies, held by suction during dosing, were inspected after treatment at frequent intervals for 5 hours and once on the following day. The tests were done at 20° with the materials tested dissolved in *n*-dodecane.

Most of the flies treated with a fixed dose of pyrethrum extract alone or with piperonyl butoxide remained normal for a very short time (the latent period). The number of flies knocked down increased very rapidly during the knock-down period, and reached a maximum at the knock-down end-point. Past this point a proportion of the flies knocked down recovered; the rest died. The relative and absolute durations of each of these periods were influenced by the concentration of pyrethrins and the presence of piperonyl butoxide. The interval of time between treatment and knock-down end-point was the same (10 minutes) over a wide range of concentrations when the flies were treated with pyrethrum extract alone, and the flies treated with the extract alone recovered rapidly after knock-down end-point. The synergist inhibited recovery, so that more flies died, increased the toxicity of the extract during knock-down and prolonged the duration of knock-down. The influence of piperonyl butoxide, small initially, increased with the passage of time after treatment.

Attention is drawn to some of the shortcomings of methods commonly used to compare the knock-down action of insecticides.

9.9 SAWICKI, R. M. (1962). Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. V. Knock-down activity of the four constituents with piperonyl butoxide. *J. Sci. Fd Agric.* **13**, 591–598.

The paralysis (knock-down) and the subsequent recovery or death of female house flies treated by a measured-drop method were studied with each of the four active constituents of pyrethrum extract alone and in the presence of piperonyl butoxide (1 part of pyrethroid + 10 parts of piperonyl butoxide) in *n*-dodecane as solvent at 20°.

Knock-down was faster, lasted longer and the knock-down end-point was reached later when the flies were treated with the constituents in the presence of piperonyl butoxide. The synergist increased the total efficiency of the constituents, probably because it inhibited the recovery mechanism of the flies. The effect of the synergist was least during the first few minutes after treatment; the synergistic factor increased most rapidly during the first 2 hours after treatment.

Piperonyl butoxide changed the order and the magnitude of the relative toxicities from those obtained with the constituents alone. Four minutes after treatment, when the effect of the synergist was very slight, the order of the relative toxicities of the mixtures, pyrethrin II, cinerin II, pyrethrin I, cinerin I

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was the same as for the constituents alone. Three hours later it changed to (constituents alone in brackets) pyrethrin I (pyrethrin II), cinerin I (pyrethrin I), pyrethrin II (cinerin I), cinerin II (cinerin II), and it was the same at death (24 hours after treatment). Cinerin I and pyrethrin I were synergised most, cinerin II and pyrethrin II least, both during knock-down and at death.

9.10 SAWICKI, R. M. & (THAIN, E. M.) (1962). Insecticidal activity of pyrethrum extract and its four insecticidal constituents against house flies. IV. Knock-down activities of the four constituents. *J. Sci. Fd Agric.* **13**, 292–297.

The knock-down activities of pyrethrins I and II and cinerins I and II were studied on house flies (*Musca domestica* L.) by a measured-drop technique. Unanaesthetised flies held by suction during dosage were inspected at frequent intervals for 5 hours. The tests were done at 20° with the materials tested dissolved in *n*-dodecane.

The relative toxicities of the materials, measured at ED50, differed at different times after treatment; 4 minutes and 2 hours after treatment they were, respectively: pyrethrum extract, 1·0, 1·0; pyrethrin II, 1·98, 1·58; cinerin II, 0·69, 0·51; pyrethrin I, 0·60, 1·07; cinerin I, 0·50, 0·64. The KD50 end-points were: pyrethrin II, 10 minutes; cinerin II, 11 minutes; pyrethrum extract, 13 minutes; pyrethrin I, 17 minutes; cinerin I, 20 minutes. At KD50 end-point the relative toxicities and the relative speeds of knock-down (given in brackets) were: pyrethrum extract, 1·0 (1·0); pyrethrin II, 2·16 (1·30); pyrethrin I, 0·72 (0·76); cinerin II, 0·66 (1·18); cinerin I, 0·55 (0·65). The relative toxicities of pyrethrin II and cinerin II decreased with the passage of time after treatment because flies recovered sooner from them than from pyrethrin I and cinerin I.

Possible reasons are discussed for the differences in the order of the relative toxicities of the constituents when determined by different methods.

Entomology Department

THESES

10.1 CALNAIDO, D. (1962). Studies on the abundance and dispersal of frit flies. Ph.D. Thesis, University of London.

10.2 SMITH, F. M. (1962). The behaviour of adult frit flies (*Oscinella frit* L.) in the oat crop. Ph.D. Thesis, University of London.

GENERAL PAPERS

10.3 EDWARDS, C. A. (1962). Symphylids can be serious. *Grower*, 12 May, 914.

10.4 JOHNSON, C. G. (1962). A functional approach to insect migration and dispersal and its bearing on future study. *Proc. XI int. Congr. Ent.* III, 50–53.

10.5 JOHNSON, C. G. (1962). Aphid migration. *New Scientist* **15**, 622–625.

10.6 RAW, F. (1962). Flotation methods for extracting soil arthropods. In: *Progress in Soil Zoology* I, ed. P. W. Murphy. London: Butterworths, pp. 199–201.

10.7 TAYLOR, L. R. (1962). Suction methods for sampling arthropods at and above ground level. In: *Progress in Soil Zoology* I, ed. P. W. Murphy. London: Butterworths, pp. 217–221.

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Research Papers

10.8 Banks, C. J. (1962). Effects of the ant *Lasius niger* (L.) on insects preying on small populations of *Aphis fabae* Scop. on bean plants. *Ann. appl. Biol.* **50**, 669–679.

Small populations of *Aphis fabae* were wholly or partially protected by the ant *Lasius niger*, which drove most predators away. Predators eliminated whole colonies of unprotected aphids or persistently restricted their numbers. Protection of the aphids against predators by ants is probably more important than hitherto thought, and may be more important than the other ways in which ants affect the multiplication rate of *A. fabae*.

10.9 Banks, C. J. & (Brown, E. S.). (1962). A comparison of methods of estimating population density of adult Sunn Pest, *Eurygaster integriceps* Put. (Hemiptera, Scutelleridae) in wheat fields. *Ent. exp. & appl.* **5**, 255–260.

Three methods of estimating the population density of young adult Sunn Pest were used simultaneously at two wheat fields in North Iran in 1960 when the insects, all adult, were feeding on the wheat before dispersal to hibernation quarters.

On plots of about 1,000 sq m sweeping with a hand-net estimated population density inefficiently, but the sampling errors were small; the method might be useful for comparative estimates between fields. Marking–recapture estimates had small standard errors (8–18% of the means), but the method is unnecessarily complicated, as well as being unsuitable when insects are sedentary, to make it of much practical value. Direct counting in quadrats of 1 sq m was generally the most reliable method, with standard errors of 10–15% of the means. At one plot, however, a storm drove many insects into cracks in the soil, where they could not be counted, and the population density estimated from quadrats was less than that obtained by marking–release and recapture.

10.10 Edwards, C. A. (1962). Springtail damage to bean seedlings. *Plant Path.* **11**, 67–69.

In soil-fumigation trials at Rothamsted in 1960 chloropicrin/methyl bromide mixture gave good control of a severe attack of springtail on seedlings of French beans. The damage is described. In subsequent trials against the pest on anemones good control was obtained by soil drenches of lindane and aldrin.

10.11 Edwards, C. A. (& Dennis, E. B.). (1962). The sampling and extraction of Symphyla from soil. In: *Progress in Soil Zoology*, I, ed. P. W. Murphy. London: Butterworths, pp. 300–304.

Sampling techniques, and populations estimated from them, are described. Tullgren funnels were unsuccessful, but a simple flotation method on water gave good results. More precise estimations of populations could be made by thorough sampling and the use of a modified Ladell flotation method, which is described.

10.12 Edwards, C. A. (& Dennis, E. B.). (1963). The phytotoxicity of insecticides and acaricides. Pt. II. Flowers and Ornamentals. *Plant Path.* **12**, 27–36.

A wide range of commercial pesticides were applied at once, twice and five times normal dosage rates (all with an equivalent quantity of wetter) as sprays or root drenches to some 15 commonly grown outdoor and greenhouse ornamental plants. The development and form of the phytotoxic symptoms of the various plants are fully described. Safe chemicals for each crop are listed, with

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the minimum phytotoxic dosages of other materials. Where chemicals cause a particular type of damage this is described. Generally outdoor plants were less damaged than those in the greenhouse.

10.13 EDWARDS, C. A. & HEATH, G. W. (1963). The role of soil animals in breakdown of leaf material. In *Soil Organisms: Proceedings of Colloquium on soil fauna, soil microflora and their relationships* (1962). Amsterdam. (In the press.)

Breakdown of leaf tissue was investigated by assessing the diminishing area of leaf disks placed in litter or buried in nylon bags of different meshes which excluded some animals and allowed others to enter. Earthworms eroded disks three times faster than did small invertebrates, most important of which were springtails, enchytraeids and dipterous larvae. Oak disks disappeared faster than beech. Some disks cut from leaves picked from trees in September became tanned, and remained uneaten, while untanned ones were greatly eroded. When animals were completely excluded for 9 months leaves showed no signs of breakdown.

10.14 FRENCH, R. A. (1962). Migration Records 1959. *Entomologist* **95**, 169–177.

10.15 FRENCH, R. A. (1962). Migration Records 1960. *Entomologist* **95**, 204–211.

10.16 FRENCH, R. A. (1963). Migration Records 1961. *Entomologist* **96**, 32–38.

10.17 HEALY, M. J. R. & TAYLOR, L. R. (1962). Tables for power-law transformation. *Biometrika* **49**, 557–559. (For summary see Statistics Department No. 12.16)

10.18 RAW, F. (1962). Studies of earthworm populations in orchards. I. Leaf burial in apple orchards. *Ann. appl. Biol.* **50**, 389–404.

The amount of leaf litter buried by worms between leaf-fall and spring was measured in five grassed and two arable orchards near Wisbech, Cambs. A known number of weighed leaves were placed on the ground beneath wire cages at leaf-fall, and again several weeks later; those remaining at the end of each period were weighed and counted. In grassed orchards the number and weight of leaves buried were closely correlated with the fresh weight of *L. terrestris*, estimated from the number brought to the soil surface by dilute formalin. Some orchards had $\frac{3}{4}$–1 ton fresh weight of *L. terrestris*/acre, and in these over 90% of the normal leaf-fall ($\frac{1}{2}$ ton dry weight/acre) was buried during winter.

Leaves were buried more rapidly in arable than in grassed orchards, probably because they were the only ones present and were easier for worms to find and bury when there was no grass. Twice as many leaves were buried from cages initially containing 200 leaves as from cages containing 100 leaves.

The rate at which *L. terrestris* buried leaves was correlated with soil temperature.

The long-term effect of leaf burial was shown by the contrasting soil profiles of a typical grass orchard and one where *L. terrestris* is rare and crumb structure poor and where the accumulated remains of up to 15 years leaf-fall now form a surface mat $\frac{1}{2}$–$1\frac{1}{2}$ in. thick.

10.19 STEPHENSON, J. W. (1962). A culture method for slugs. *Proc. malac. Soc. Lond.* **35**, 43–45.

A method of handling eggs, rearing many slugs suitable for molluscicide screening and maintaining breeding cultures is described.

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10.20 STEPHENSON, J. W. (1962). The molluscicidal properties of three fly repellents. *Plant Path.* **11**, 25–27.

Four methods for testing the molluscicidal property of dimethyl phthalate, dibutyl phthalate and benzyl benzoate, and the results of tests are described. All three compounds were either toxic or repellent to slugs, depending on the concentration used; in concentrations lethal to slugs the substances were also phytotoxic, and could not therefore replace metaldehyde for practical control.

10.21 STEPHENSON, J. W. (1962). An improved final sieve for use with the Salt and Hollick soil-washing apparatus. In: *Progress in Soil Zoology*, I, ed. P. W. Murphy. London: Butterworths, pp. 202–203.

A sieve with an easily removable sieve plate is described. The mesh can be changed according to the size of the animals required, with appreciable saving of time when washing many samples.

10.22 TAYLOR, L. R. (1962). The absolute efficiency of insect suction traps. *Ann. appl. Biol.* **50**, 405–421.

The ways in which insect size, sampling rate and velocity, and wind speed affect the efficiency of suction traps were measured and an expression obtained to give total efficiency of capture for most insects caught in most traps at most wind speeds. A table is given for converting log catch/hour directly into log density/10^6 cu ft air for 9-, 12-, 18- and 30-in. traps, corrected for changes in volume of air sampled and for losses in efficiency under various working conditions.

In an appendix a net is described that samples isokinetically in high winds and works efficiently as a whirligig trap in low winds.

10.23 TAYLOR, L. R. (1962). The efficiency of sticky insect traps and suspended nets. *Ann. appl. Biol.* **50**, 681–685.

The efficiency with which the 5-in.-diam. white cylindrical sticky trap and suspended tow-net catch insects was assessed using Johnson's (1950) field comparison of the two with results from the suction trap recently standardised by Taylor (1962). The aerodynamic efficiency of the sticky trap was also calculated from Gregory's (1951) results. Small insects behave very like inert particles during capture, and the efficiency of the sticky trap is almost constant in winds from 2 to 10 m.p.h. Tables are given converting catch of small insects to aerial density in winds from 1 to 10 m.p.h.

10.24 TAYLOR, L. R. (1963). Analysis of the effect of temperature on insects in flight. *J. Anim. Ecol.* **32**, 99–117.

The number of insects in free flight depends on the size of the total population and on the proportion flying: both are affected by temperature. Analysis shows, however, that once temperature is above a threshold for take-off (or for flight) the duration of temperature above this has more effect than the mean temperature on numbers caught each day. Effects of population changes on catch can be largely eliminated by classifying trap catches as zero or positive. A graph of catch against temperature then gives a threshold, and field measurements of thresholds made in this way can be as accurate as laboratory measurements.

Regression analysis is not appropriate for populations of single species where temperature effects are largely "all or none"; but it can be used for populations consisting of several species where there is a scatter of thresholds

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Bee Department

Book

11.1 Butler, C. G. (1962). *The world of the honeybee*. Revised edition. (New Naturalist series.) London: Collins.

General Papers

11.2 Butler, C. G. (1962). Some recent work on bee behaviour. *Proc. R. Soc. Med.* **55**, 545–548.

11.3 Free, J. B. (1962). Studies on the pollination of fruit trees by honeybees. *J. R. hort. Soc.* **87**, 302–309.

11.4 Free, J. B. (1962). The foraging behaviour of honeybees in relation to pollination. *Rep. cent. Ass. Brit. Beekeep. Ass.* 1–10.

Research Papers

11.5 Bailey, L. & Gibbs, A. J. (1962). Cultural characteristics of *Streptococcus pluton* and its differentiation from associated enterococci. *J. gen. Microbiol.* **28**, 385–391.

Strains of *Streptococcus pluton* (White) from widely separate parts of the world were very similar culturally and serologically and differed greatly in these respects from associated enterococci. *S. pluton* was satisfactorily isolated only on a yeast + glucose + potassium phosphate + starch medium incubated anaerobically + CO_2. Oxidation potentials in agar of this medium were very stable, for which the high concentration of phosphate, together with yeast and glucose, was necessary. In deep agar incubated aerobically *S. pluton* started to grow only within a narrow range of Eh values. It did not grow on ordinary bacteriological media, but was adapted to grow on the special agar in air + CO_2. Adapted strains grew on the special agar in a limited volume of air and produced CO_2.

11.6 Bailey, L. & Lee, D. C. (1962). *Bacillus larvae*: its cultivation *in vitro* and its growth *in vivo*. *J. gen. Microbiol.* **29**, 711–717.

Spores of *Bacillus larvae* White germinate and make initial vegetative growth best in a limited range of low redox potentials, but later growth and sporulation occur best aerobically. Different media needed for best results with each phase of development of the bacillus are described. Spores of *B. larvae* germinate in the mid-gut contents of honeybee larvae up to 2 days old. The vegetative forms then migrate and become closely applied to, but do not penetrate, the mid-gut epithelium. Most organisms seem to be voided with the contents of the intestine when an infected larva defaecates shortly before it pupates. A few organisms are presumably left in the intestine and probably invade the tissues of the larva as it pupates.

11.7 Butler, C. G. & (Paton, P. N.) (1962). Inhibition of queen rearing by queen honeybees (*Apis mellifera* L.) of different ages. *Proc. R. ent. Soc. Lond.* (A) **37**, 114–116.

The quantity of 9-oxodecenoic acid from individual virgin and mated queens, of different ages, was measured by gas chromatography. A very young queen has little, but has developed about 130 μg when 5–10 days of age, and continues to have about this amount until she is old or, perhaps, is about to be superseded or to swarm. The poor ability of a virgin queen 7–21 days old to inhibit queen

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rearing is not because 9-oxodecenoic acid is lacking, but probably because "inhibitory scent" is deficient.

11.8 FREE, J. B. (1962). The effect of distance from polliniser varieties on the fruit set on trees in plum and apple orchards. *J. hort. Sci.* **37**, 262–271.

The fruit set on plum trees decreased greatly with increase in distance from polliniser trees, and less so with increase in distance from honeybee colonies. Trees adjacent to pollinisers had a greater set on the sides facing the pollinisers than on their far sides. Parts of trees touching "bouquets" had a greater set than parts without bouquets.

In an apple orchard with main variety and polliniser trees in separate blocks the fruit set was greater on the main variety trees adjacent to the pollinisers than on trees farther away. In an apple orchard with a polliniser tree as every third tree in every third row main variety trees had a greater fruit set, more seeds per fruit and more carpels with seeds per fruit on the sides near to their adjacent polliniser than on their far sides. The fruit set, seeds per fruit and number of carpels with seeds per fruit was greater the nearer the trees were to the adjacent polliniser.

These findings are discussed in relation to the foraging behaviour of honeybees and methods of arranging polliniser and main variety trees in orchards.

11.9 FREE, J. B. (1962). The behaviour of honeybees visiting field beans (*Vicia faba*). *J. Anim. Ecol.* **31**, 497–502.

Honeybees make three types of visit to field beans: (1) to the extra-floral nectaries only ("a" visits); (2) to obtain nectar through holes at the flower bases ("b" visits); (3) enter the flowers and mostly collect pollen and nectar ("c" visits). Most bees made visits of only one type; some made "a" and "b" visits, or "b" and "c" visits, either on the same or on different foraging trips, but very few made "a" and "c" visits. The relative proportions of the foraging populations making the various visits differed on different days and at different times of the same day; the differences mostly resulted from changes in the bees present and not from changes in the behaviour of individuals.

11.10 SIMPSON, J. (1960). Induction of queen rearing in honeybee colonies by amputating their queens' front legs. *Bee World* **41**, 286.

Amputating the front legs of 13 queens caused their colonies to begin queen rearing. Although all but one of the colonies eventually succeeded in rearing one or more queens to maturity, most made several abortive attempts at first. Two colonies swarmed (in June) with young queens. In all the others that successfully reared queens young queens eventually replaced the old ones without swarming. In the last group treated (in late July) the supersedures were fully efficient, i.e., the old queens survived until the young ones had begun laying.

Statistics Department

GENERAL PAPERS

12.1 LEECH, F. B. (1962). Statistics in relation to veterinary science. *Vet. Ann.*, 35–39.

12.2 YATES, F. (1962). Obituaries of Sir Ronald Aylmer Fisher. *Nature, Lond.* **195**, 1151–2; *Biometrics* **18**, 442–447; *J. R. statist. Soc. A, Rev. Inst. int. Statist.* **30**, 280–282.

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Research Papers

12.3 (Bogert, B. P.), Healy, M. J. R. & (Tukey, J. W.) (1963). The quefrency alanysis of time series for echoes. *Proc. Conf. Time Series*, Brown University, U.S.A., 1962. (In the press.)

Techniques based on Fournier analysis proved useful in problems easily stated in terms of frequencies. This paper studies the application of similar techniques to echo-detection and determination of time-delays. Superimposing a more or less distorted echo upon a stationary time series adds a cosinusoidal ripple to the log power spectrum of the series. The parameters of the ripple (which by analogy we call quefrency, gamnitude and saphe) are simply related to those of the echo—in particular, the quefrency (the reciprocal of the peak-to-peak distance in cycles per second) is equal to the delay. Known techniques for studying periodic phenomena obscured by noise can thus be applied to echo detection, and by applying these techniques to the estimated power spectrum of a stretch of time series, just as would normally be done to the series itself, we can calculate and examine the cepstrum which is expected to peak at the quefrency of an echo. We can also apply complex dedomulation to the log power spectrum, when an echo is expected to produce stretches of saphe that vary linearly with frequency.

These techniques have been applied with considerable success to artificial series in which distortion had rendered known echoes more or less unrecognisable by ordinary means. Applications to seismic records, for which purpose the study was initiated, were less successful.

An appendix studies the hand digitisation of analogue records. It is shown that the process is liable to introduce substantial extraneous energy at high frequencies.

12.4 Boyd, D. A., Church, B. M. & Hills, Mary G. (1963). Fertiliser use on grassland in England and Wales. *J. Brit. Grassl. Soc.* **18**, 18–28.

The paper describes the fertilising of grassland as shown by surveys done in 1957–60.

About a third of the total consumption of N and K and almost half the total consumption of P is on grassland. Fertiliser use on leys has increased rapidly in recent years, and the average rate of application is now of the order of 0·3 cwt each of N, P_2O_5 and K_2O per acre per annum; permanent grass receives about half as much P and very much less N and K than the leys.

Generally speaking, more N and K was used per acre of grassland in arable districts than in livestock districts, and on dairy farms than on rearing and feeding farms. However, rearing and feeding farms received more P per acre of grass (in particular, more basic slag) than arable farms. Little farmyard manure was used on grassland in the arable districts, whereas in the dairy counties of the western half of England and in Wales it formed a substantial part of the total plant nutrients supplied to grassland, particularly on fields mown for hay.

The types of fertilisers used and when they were applied are also described; about four-fifths of the nitrogen was applied between February and April.

12.5 Church, B. M., (Dadd, C. V. T., Miller, T. E. & Page, J. B.) (1962). Herbicide practice in arable farming districts of Eastern England, 1959–60. *Weed Res.* **2**, 153–164.

Information on the use of herbicides in the 1959–60 crop year was collected from a stratified random sample of farms in each of four arable farming districts in Eastern England. In each of the surveyed districts 80–90% of the area under

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cereals, 10–20% of other tillage crops and about 10% of the grassland was treated with herbicides.

MCPA was the most widely used herbicide on cereals, but in two of the four districts mecoprop was also often used. Manufacturers' recommendations for rates of application were followed fairly closely for MCPA on cereal crops which were not undersown, but MCPA was also used on much of the undersown cereals in spite of the risk of damage to legumes. MCPB and mecoprop were often applied to cereals at rather lower rates than those generally recommended.

The herbicides used were usually appropriate for the weeds they were intended to control, and nine out of every ten farmers asked were satisfied with the results of treatment; detrimental effects on crops were rarely noted. Little detailed information was obtained about when herbicides were applied, but clearly most farmers were influenced more by general crop appearance (and possibly date) than by the stage of growth of crop or weeds.

12.6 CHURCH, B. M., (KINSEY, C. & POWELL, T. R. W.). (1962). Surveys of herbicide practice in two dairy farming districts, 1961–62: *Proc. 6th British Weed Control Conference* 1962. (In the press.)

Information on herbicide practice in 1960–61, obtained from surveys in Cheshire and N. Somerset, is presented and compared with results of earlier surveys. Herbicides were used during the survey year on less than a third of the farms in these grassland-dairying districts and 7% of the total crops and grass acreage was treated.

A third of the farmers in these districts had a weed-control problem on grassland for which they had no satisfactory solution, and several farmers expressed doubts about the value of using herbicides on pasture.

12.7 (EDEN, T.), GOWER, J. C. & (SALGADO, M. L. M.) (1962). A factorial fertiliser experiment on coconuts. *Emp. J. exp. Agric.* (In the press.)

Yields of copra and nuts for each of 26 years of a $3 \times 3 \times 3$ factorial (N, P, K) trial on coconuts are analysed for each year separately and also combined in a complete analysis. Trees on plots not receiving potash deteriorated, so that after 10 years the potash manuring was uniformly increased on all plots. The main effects and interactions of the treatments are discussed—the responses for nuts and copra are similar, with only potash having any large effect. Manuring did little to raise the absolute yields over the period.

There was great variation from year to year in absolute yields, but no significant correlation was found between these yields and seasonal rainfall.

12.8 GOWER, J. C. (1963). An autocode for table manipulation. *Proc. Symposium on Symbolic Language in Data Processing*, Rome 1962, 613–624.

A short summary of the disadvantages of using standard autocodes for table manipulation leads to the concept of scanning. Autocode instructions, based on a scan subroutine, are given, and examples show how they can be economically used for quite complex calculations.

12.9 GOWER, J. C. (1962). The estimation of variance components in hierarchical analyses. *Biometrics* **18**, 537–542.

The paper describes a systematic method for computing the coefficients of the variance components of the expected mean squares in a hierarchical analysis of variance, together with a simple method of pooling if the outermost hierarchy is analysed separately for each of its categories. The programming of the computation for electronic computers is briefly discussed.

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12.10 (GRUCHY, C. L., MCCALLUM, G.), VESSEY, M. P., (PARR, W. H. & ALLCROFT, R.) (1963). An investigation of the value of five treatments for acetonaemia in Jersey cows. *Vet. Rec* **75**, 183–188.

In 1956 an investigation was undertaken in Jersey, C.I., to compare the effects of dextrose, glycerine, potassium chlorate and sodium propionate on clinical acetonaemia affecting cows of the Jersey breed. Ten cows were also treated with cortisone or A.C.T.H. No important differences were observed between the treatments.

The trial has, however, been of particular value as a pilot investigation. Suggestions for planning future work are made.

12.11 HEALY, M. J. R. (1963). Programming multiple regression. *Comput. J.* **6.**

Multiple regression, one form of estimation by least squares, is an important statistical technique. Much computing is involved, and many programmes have been written to do the necessary work—so many that it is clear that most of them do not attain an adequate degree of generality. This paper outlines the essential features of regression analysis and attempts to give the essential requirements for a general programme.

12.12 HEALY, M. J. R. (1963). Fiducial limits for a variance component. *J. R. statist. Soc. B.* (In the press.)

If samples of equal size k are taken from some groups randomly chosen from a population of groups, the variance θ^2 of the population of group means can be estimated by $(V_1 - V_2)/k$, where V_1, V_2 are the mean squares between and within groups in an analysis of variance. R. A. Fisher showed in 1936 that the fiducial distribution of θ^2 could be derived from the joint distribution of two independent χ^2 variates. The distribution has as parameters n_1 and n_2, the degrees of freedom of V_1 and V_2, and $F = V_1/V_2$, the variance ratio. It has been tabulated for n_1, $n_2 = 6, 8, 12, 24, \infty$ and $F = 0{\cdot}5, 1, 2, 4, 8, 16, \infty$. Tables of percentage points for $P = 99\%, 95\%, 5\%$ and 1% will appear in the 6th edition of Fisher and Yates' *Statistical Tables*.

12.13 HEALY, M. J. R. (1963). A subject index to the Kendall–Doig Bibliography of Statistical Literature. *J. R. statist. Soc. A.* (In the press.)

The 10,000 titles listed by Kendall and Doig were classified, each under one or more of 200 headings covering topics of statistical theory and fields of application. It is intended to maintain the index on magnetic tape and to consult it by means of the Orion computer.

12.14 HEALY, M. J. R. & (BOGERT, B. P.) (1963). Fortran subroutines for time-series analysis. *Comm. Assoc. Comp. Mach.* **6**, 32–34.

A set of Fortran subroutines is described which enables a wide variety of time-series problems to be programmed expeditiously. The construction of general statistical programmes is discussed.

12.15 HEALY, M. J. R. & (JONES, E. L.) (1962). Wheat yields in England, 1815–59. *J. R. statist. Soc. A.* **125**, 574–579.

The Royal Statistical Society's library contains two MS notebooks containing a record of wheat yields in 40 districts of England from 1821 to 1859 obtained by actual crop-cutting. There are also copies of letters describing the process of obtaining the crop samples. The record turns out to be that used by T. Tooke in his *History of Prices*, Vol. 5. A summary of the figures is given and their implications are briefly discussed.

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12.16 HEALY, M. J. R. & TAYLOR, L. R. (1962). Tables for power-law transformations. *Biometrika* **49**, 557–559.

Taylor showed that in many biological contexts, the variance v of the number of organisms per sample is related to the mean m by a power relation $v = am^b$. When this is so a transformation to stabilise the variance takes the form $z = (x + c)^p$, where x is the original observation, c is a constant and $p = 1 - \frac{1}{2}b$. The square-root and logarithmic transformations are special cases. Tables are given of x^p with $x = 0\,(1)\,100$, $p = 0{\cdot}2\,(0{\cdot}2)\,0{\cdot}8$ and of $10\,(1 - x^{-p})$ with $x = 1\,(1)\,100$, $p = 0{\cdot}2\,(0{\cdot}2)\,0{\cdot}8$ to enable the transformation to be easily applied.

12.17 MILK MARKETING BOARD (1962). *The National Dairy Herd: Interim Census*, 1960.

In 1955, when the Milk Marketing Board conducted their first census of dairy herds, it was thought a similar census every 10 years or so would keep pace with the changes in the structure of dairy herds. This, however, did not prove to be so, and it was decided, therefore, to conduct an interim census in 1960 based on a sample of milk selling herds. The large changes revealed, particularly in breed and herd size, are described.

12.18 PATTERSON, H. D. & ROSS, G. J. S. (1963). The effect of block size on the errors of modern cereal experiments. *J. agric. Sci.* **60**. (In the press.)

The errors of 454 cereal experiments organised by the National Institute of Agricultural Botany between 1956 and 1960 are examined in relation to block size. All the experiments used long, narrow plots and were harvested by combine. The most important conclusion is that the gain in efficiency by using small blocks in cereal experiments is as great now as it was before combine-harvesting and long, narrow plots were introduced. An empirical rule is that the variance per plot is roughly proportional to $n^{\frac{1}{2}}$, where n is the number of plots per block.

12.19 (REEVE, E. C. R.) & ROSS, G. J. S. (1962). Mate-killer (*Mu*) particiles n *Paramecium aurelia*: the metagon division hypothesis. *Genet. Res., Camb.* **3**, 328–330.

Mate-killer (*Mu*) particles in *Paramecium aurelia* depend on the presence of the dominant genes M_1 and M_2. On elimination of these genes there is a delay of 8–15 fissions before most of the daughter cells lose their particles. The *Mu* particles are thought to depend on intermediary particles (metagons) which are maintained by the *M*-genes. The simple theory that the normal cell contains many metagons which, on loss of the genes, are passively diluted out during subsequent fissions was shown to be inadequate. A modification is proposed in which a certain proportion of the metagons divide during each interfission period. The probability of division and the original numbers of metagons are estimated and the agreement with the data is satisfactory.

12.20 (REEVE, E. C. R.) & ROSS, G. J. S. (1963). Mate-killer (*Mu*) particles in *Paramecium aurelia*: further mathematical hypotheses regarding metagon distribution. *Genet. Res. Camb.* **4**. (In the press.)

The hypothesis that metagons are originally clumped together in twos and threes is inadequate. The hypothesis that the metagons are distributed with unequal probability between the two products of a fission fits the basic data well, but fails to fit the results of a subsequent experiment in which paramecia of the eleventh fission are observed through three subsequent fissions. This last experiment tends to support the division hypothesis.

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12.21 (SMITH, C.), (KING, J. W. B.) & GILBERT, N. (1962). Genetic parameters of British Large White bacon pigs. *Anim. Prod.* **4**, 128–143.

Estimates of heritabilities and genetic correlations among 35 measurements and scores of British Large White bacon pigs are reported. No serious antagonisms exist with regard to improvement by selection. The correlations between 24 of the more important traits are summarised by principal component analysis.

12.22 YATES, F., GOWER, J. C. & SIMPSON, H. R. (1963). A specialised autocode for the analysis of replicated experiments. *Comput. J.* **5**, 313–319.

The paper describes a general programme, written for the Elliott 401, for the analysis of orthogonal or nearly orthogonal data, such as arise from replicated experiments. This is in essence a specialised autocode for performing on tables the types of operation required in such analyses, and is similar to Part 2 of our General Survey Programme. Modifications and extensions planned for the Orion are briefly discussed.

12.23 YATES, F., VERNON, A. J. & (NELSON, S. W.) (1963). An example of the analysis of uniformity trial data on an electronic computer. *Emp. J. exp. Agric.* (In the press.)

The paper gives an example of the use, for the analysis of the data of a uniformity trial on maize, of a general programme for the analysis of replicated experiments written for the Rothamsted electronic computer. The errors associated with plots of different sizes and shapes, with and without guard plants, and with differing degrees of local control, were determined. Most of the variability in the trial could be ascribed to random variation between plants, so the use of very small plots would not be advantageous.

Field Experiments Section

RESEARCH PAPER

13.1 GARNER, H. V. (1962). Experiments with farmyard manure, sewage sludges, and town refuses on microplots at schools, 1940–9. *Emp. J. exp. Agric.* **30**, 295–304.

The direct and residual effects of dung and several types of sewage sludge and town refuses were measured in 73 microplot experiments in presence and absence of inorganic nutrients. Most of the experiments, which were usually repeated for several years on the same plots, were with potatoes, but other vegetable crops were included. At the rates used dung was much better than any of the other materials for all crops except cabbages and kale, for which sludges were very effective. In the potato experiments sludges were shown to be good sources of nitrogen; they also supplied phosphate, but very little potash. Repeated applications of organics on the same plots gave large residual effects in the first year of test. Sewage sludge gave bigger residues than dung when no fertiliser nitrogen was applied to the test crop.

The experiments showed that with careful management useful information on bulky organic manures could be derived from replicated experiments on plots of about 0·005 acre.

Woburn Experimental Station

15.1 BARNES, T. W. (1962). Growing good grass. Grass needs water—but how much? *Dairy Farmer*, March 1962, pp. 49–50 & 67.

The results from nine years of experimental irrigation of grass are given as a guide for farmers.

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Broom's Barn Experimental Station

General Papers

16.1 Byford, W. J. (1962). Broom's Barn Experimental Station. *Commonw. Phytopath. News* **8**, 51–53.

16.2 Dunning, R. A. (1962). Insecticides for control of aphids and yellows. *Brit. Sug. Beet Rev.* **30**, 133–135.

16.3 Dunning, R. A. (1962). Will spraying be necessary for aphid and yellows control in 1962? *Farming World*—Sugar-beet supplement, March, p. 16.

16.4 Dunning, R. A. (1962). Systemic insecticides and sugar-beet yellows. *Agriculture, Lond.* **69**, 356–361.

16.5 Dunning, R. A. (1962). Insecticides and fungicides used to control sugar-beet pests and diseases. *Chem. & Ind.* **4**, 155–158.

16.6 Dunning, R. A. (Page, A. B. P., Lubatti, O. F., Mainwaring, A. & Baker, C.) (1962). A progress report on the control of aphids in mangold clamps by methyl bromide fumigation. *Proc. Brit. Insect. Fung. Conf. Brighton*, 1961, **1**, 135–136.

16.7 Dunning, R. A. & Winder, G. H. (1962). Comparison of aphicides, especially granular systemics for control of beet yellows. *Proc. Brit. Insect. Fung. Conf. Brighton*, 1961, **1**, 93–106.

16.8 Heathcote, G. D. (& Eastop, V. F.). (1962). Notes on some aphids from British North Borneo. *Ent. mon. Mag.* **98**, 97–98.

16.9 Hull, R. (1962). Sugar-beet yellows in Great Britain, 1961. *Plant Path.* **11**, 183.

16.10 Hull, R. (1962). Broom's Barn Experimental Station. *Nature, Lond.* **195**, 1261–1262.

16.11 Hull, R. (1962). Spraying for control of yellows in 1962. *Brit. Sug. Beet Rev.* **31**, 22.

16.12 Hull, R. (1962). Factors that influence sugar content. *Brit. Sug. Beet Rev.* **31**, 27–29.

16.13 Hull, R. (1962). Control of sugar-beet yellows. *Proc. Brit. Insect. Fung. Conf. Brighton*, 1961 **1**, 87–92.

Research Papers

16.14 Byford, W. J. (1963). Experiments on the use of ethyl mercury phosphate and other materials for treating sugar-beet seed. *Ann. appl. Biol.* **51**, 41–49.

Steeping sugar-beet seed in ethyl mercury phosphate solution controlled *Pleospora betae* and increased the emergence of seedlings in the field more than did "short-wet" fungicide treatments, spraying EMP solution on to the seed or steeping in other fungicides.

16.15 Heathcote, G. D. (1962). The suitability of some plant hosts for the development of the peach-potato aphid, *Myzus persicae* (Sulzer). *Ent. exp. & appl.* **5**, 114–118.

M. persicae developed well on *Brassica* species, particularly those that grow rapidly, such as mustard and turnip, but much less well on sugar beet, spinach

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and lettuce. They usually develop better on young, rapidly growing leaves than on mature leaves. Two clones of *M. persicae* behaved similarly on the host plants tested.

Soil Survey of England and Wales

Book

17.1 Soil Survey Staff (1960). *Soil Survey of Great Britain: Field Handbook*. (Edited by E. Crompton.) Harpenden: Soil Survey of Great Britain.

General Papers

17.2 *Soil Map of Wells*, Sheet 280 (3rd edition). Southampton: Ordnance Survey, 1962.

17.3 *Soil Map of Weston-super-Mare*, Sheet 279 (3rd edition). Southampton: Ordnance Survey, 1962.

17.4 Avery, B. W. (1962). Classification of soils. *ASLIB Proc.* **14**, 234–238.

17.5 Avery, B. W. (1962). Soil type and crop performance. *Soils & Fert.* **25**, 341–344.

Research Papers

17.6 (Boaler, S. B.) & Hodge, C. A. H. (1962). Vegetation stripes in Somaliland. *J. Ecol.* **50**, 465–474.

In the western part of the former Somaliland Protectorate patterns of parallel stripes of vegetation separated by lanes of bare or nearly bare ground occur. The stripes and lanes are several miles long, from 50 to 200 yards wide and run in straight lines up and down the direction of steepest slope. They occur in *Acacia bussei–Chrysopogon aucheri* or *Acacia tortilis–Andropogon cyrtocladus* bush communities and in *Chrysopogon aucheri* grassland. The soils of the bare lanes are coarser-textured and have a deeper top-soil than the adjoining vegetation stripe soils. Soluble salts are leached to a greater depth in the lanes. The vegetation patterns are thought to depend on the texture of the soil parent material.

17.7 Rudeforth, C. C. (1962). An illuminated polishing table for preparing thin sections of soils. *J. Soil Sci.* **13**, 247–248.

A source of polarised light below a glass polishing plate facilitates the rapid assessment of section thickness using the birefringence colours of mineral grains seen through a hand lens fitted with a second polariser.

17.8 Storrier, R. R. & Muir, A. (1962). The characteristics and genesis of a ferritic brown earth. *J. Soil Sci.* **13**, 259–270.

The surface soil of the Banbury clay loam is a moderately to slightly acid, well-structured, brown clay loam. With depth both structure and texture become coarser; the lower (B) horizons are characterised by a stone-line, probably resulting from frost action. The profile examined shows no evidence of contamination by extraneous material. Weathering has taken place *in situ*, and the clay minerals are derived from the parent material.

The sequence of soil formation appears to be: chemical weathering of the solid rock with conversion of siderite and chamosite to goethite, followed by physical breakdown of the rock and redistribution of iron among the different particle-size fractions. The redistribution is caused by mobilisation, translocation and flocculation of iron oxide, particularly in the coarser clay fraction and most noticeably in the $(B)_2$ horizon. Iron has also been lost from the soil.

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