ROTHAMSTED RESEARCH

Report for 1958

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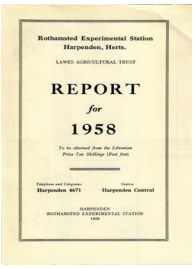

Departmental Publications / Abstracts of Papers

Rothamsted Research

Rothamsted Research (1959) *Departmental Publications / Abstracts of Papers ;* Report For 1958, pp 235 - 277 **- DOI: https://doi.org/10.23637/ERADOC-1-91**

PUBLICATIONS

Physics Department

1.1. CASHEN, G. H. (1959). Electric charges of kaolin. *Trans. Faraday Soc.* **55**, 477–486.

Two methods of measuring the negative charge of kaolin, using cetyl trimethyl ammonium bromide, have shown that kaolin possesses a permanent isomorphous replacement charge. The presence of positive edge charges in acid conditions has been confirmed. It is suggested that the release of aluminium from acid-washed clays is a consequence of the formation of these edge charges, the crystals becoming unstable as electrolyte is washed away and the potential difference between the planar and edge faces rises.

1.2. DETTMANN, Margaret G. (1958). Water uptake by pure clays and soil crumbs. *J. Soil Sci.* **9**, 306–315.

Wetting experiments on pure clays are described that lead to the conclusions that entrapped air is neither a necessary nor an important factor in slaking of dry soils, and that slaking is always associated with rapid intercrystalline swelling of the clay. If swelling is suppressed, or takes place slowly—as from a vapour phase—slaking does not occur, and it is suggested that slow swelling gives time for readjustment of the internal geometry of the clay, so producing some dislocation but no disruption. In *N*-NaCl a Na-montmorillonite swells to about twice its dry thickness, and in an atmosphere of 98 per cent relative humidity it gains about one-third of its weight. Both these figures are in agreement with the usual estimate of surface area of 800 sq. m./g. Under the same conditions a Na-illite (from Willalooka) swells by about a third of its dry thickness, and gains about a quarter of its dry weight.

Studies on rates of uptake of water vapour indicate that montmorillonite has taken up less than a quarter of its equilibrium water content at 98 per cent relative humidity within 10 minutes, whereas illite has taken up one-third of its water in the same time, the clays being stable against subsequent flooding.

In the field it is probable that water vapour diffuses ahead of a liquid wetting front, and the protective effect of the resultant slower pre-swelling of the clay prevents the slaking action of rain from affecting more than a thin surface layer of soil.

1.3. DETTMANN, MARGARET G. & EMERSON, W. W. (1959). A modified permeability test for measuring the cohesion of soil crumbs. *J. Soil Sci.* **10**.

The technique previously described (Emerson (1955) *J. Soil Sci.* **6**, 160) has been improved. A 1-cm. thickness of soil crumbs of standard size (1–2 mm. diameter) is supported on a 1-cm. layer of glass spheres (0·5–1 mm. diameter), and the permeability measured by percolation of 0·05*N*-NaCl—the so-called " initial " test. Then 3 litres of the same solution are percolated in 24 hours, after which the permeability measurement is repeated—the " final " test. The ratio, K_2/K_1, of final and inital permeabilities of the crumbs is regarded as a measure of soil cohesion.

The technique has been applied to a wide range of soils, on some of which other structural tests had already been made. The results, in four tables, show: (*a*) a continuous arable system produces very bad structure; (*b*) a short-term ley produces an improvement—as does wheat—and some of the improvement is detectable after a subsequent year in arable cultivation; (*c*) attainment of maximum stability is very slow, for apparently 100 years in grass is not long enough; (*d*) farmyard manure residues produced an increase in crumb stability on a clay soil, but no detectable increase on a sand; (*e*) a ley, and lucerne too, produces a greater increase than root crops.

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Limitations of the test are: (*a*) it should not be used unless the soil acidity is approximately the same for all samples. Very acid clay (pH 4–5), known to possess a very poor structure, gives a value of K_2/K_1 close to unity. (*b*) It may not be safe to compare soils of differing clay content. A poorly structured sandy loam (12 per cent clay) gives a much higher value of K_2/K_1 than a clay loam (31 per cent clay) that field experience would assess as having the better structure.

1.4. MONTEITH, J. L. & OWEN, P. C. (1958). A thermocouple method for measuring relative humidity in the range 95–100 per cent. *J. sci. Instrum.* **35**, 443–446.

At high relative humidities a current of 30 mA through a 38 S.W.G. chromel-*p*/constantan thermocouple produces sufficient Peltier cooling to form a film of water on the junction which may then be used as the wet-bulb of a psychometer. The wet-bulb depression can be read to 0·001° C. and in the range 97–100 per cent changes of 0·01 per cent relative humidity can be detected.

After calibration over sodium chloride solutions the psychrometer has been used to determine the water content/free energy curves of two soils, and good agreement has been obtained with previous determinations by other methods.

1.5. PENMAN, H. L. (1959). Notes on the water balance of the Sperbelgraben and Rappengraben. *Mitt. schweiz. Anst. forstlich. Versuchsw.* **35** part 1 (Festschr. 70. Geburtstag, Hans Burger), 99–109.

Twenty-five years' data for the two catchments are available as rainfall (*N*) and runoff (*A*). For the forested Sperbelgraben the values of *N*–*A* are greater than those for the mainly grassland Rappengraben, both in annual totals and in mean monthly values. Making the assumption that the annual water balance for each catchment is not greatly different from one year to the next, the annual data are statistically treated to give a correction factor for *A* for each catchment. Applying the correction brings the annual water balances into near agreement, closer than the variation from year to year in either; brings the mean monthly balances to almost exact agreement, and introduces a surprising degree of identity in the short period (2 or 3 days) responses of the catchments to rain.

The monthly and annual mean values of *N*–*A* are compared with empirical and theoretical estimates based on weather data (Turc, Thornthwaite and Penman). All three of these estimates are in broad agreement as giving the expected mean value of *N*–*A* as near 500–550 mm./annum, with the forested area losing perhaps 10–15 per cent more than the grassland; the corrected value of the means is about 625 mm./annum for both; and the observed values, uncorrected, are 860 and 695 mm. respectively.

Chemistry Department

GENERAL PAPERS

2.1. BENZIAN, B. (1957). Nutrition problems in forest nurseries. Copper deficiency in poplar. Summary report for 1956. *Rep. For. Res. For. Comm. for 1956/57*, p. 98.

2.2. COOKE, G. W. (1958). Soils and fertilizers. *J.R. agric. Soc.* **119**, 105–121.

2.3. COOKE, G. W. (1958). Recent advances in the efficient use of fertilizers. *J. Inst. Corn. Merch.* **6**, 196–204.

2.4. MATTINGLY, G. E. G. (1957). Crops. *Rep. Progr. appl. Chem.* **42**, 566–572.

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Research Papers

2.5. Arnold, P. W. (1958). Potassium uptake by cation-exchange resins from soils and minerals. *Nature, Lond.* **182**, 1594–1595.

Some results of the interaction of both soils and micaceous minerals with sodium-, calcium-, and hydrogen-saturated cation-exchange resins are given. The extent of the extraction of potassium from the minerals by hydrogen-resin is interesting; whereas dioctahedral minerals release little of their non-exchangeable potassium to hydrogen-resin, the trioctahedral minerals suffer considerable loss of potassium. Hydrogen-resin data may prove useful in assessing the long-term ability of soils to supply potassium to crops.

2.6. Bremner, J. M. (1958). Amino sugars in soil. *J. Sci. Fd Agric.* **9**, 528–532.

The identity of the amino sugars in various soils was studied by several chromatographic techniques. Glucosamine and galactosamine were detected in every soil examined, both amino sugars being isolated as their hydrochlorides from one soil and characterized by X-ray, ultimate and paper chromatographic analysis. Observations on the decomposition of glucosamine in alkaline solution are discussed.

2.7. Cooke, G. W. (1958). The nation's plant food larder. *J. Sci. Fd Agric.* **9**, 761–772.

The crops and grass grown in the United Kingdom in any one year need about 1 million tons each of N and K_2O and about one-third as much P_2O_5. Sales of cash crops, milk and stock, and the losses involved in feeding crops and grass on farms may result in about one-third of these quantities of plant foods being lost to agriculture. Fertilizers and imported feeding-stuffs provide sufficient plant foods to balance approximately the total losses of nitrogen and potassium, and they supply much more phosphorus than is lost. These sources of plant food currently provide only half of the nitrogen and less than half of the potassium that is needed for a year's cropping. In contrast, fertilizers alone supply more phosphorus in any one year than is taken up by the crops and grass grown.

The history of the use of fertilizers in the United Kingdom is discussed. About 7 million tons of N, 17 million tons of P_2O_5 and 5 million tons of K_2O have been applied to the soils of the United Kingdom through the use of fertilizers in the last 120 years. In the 18 years from 1940 to 1957 fertilizers supplied as much nitrogen, twice as much potassium and half as much phosphorus as was applied in the previous 100 years. The surface layers of the cultivated soils of the United Kingdom contain plant foods equivalent to about 200 years' supply of nitrogen, 100 years' supply of phosphorus and 1,000 years' supply of potassium at current rates of fertilizer use. The amounts of phosphorus applied to United Kingdom soils have exceeded losses of this nutrient for at least 80 years, but only in recent years have the potassium fertilizers used been sufficient to avoid depleting soil potassium reserves. The size and nature of the reserves of soil phosphorus which have accumulated in British soils as a result of manuring tend to be more important for the nutrition of arable crops than the supply of " native " soil phosphorus. In contrast, the reserves of potassium built up by residues from purchased fertilizers and feeding-stuffs are relatively small, and the capacity of soil minerals to supply potassium to crops is very important.

Future prospects for increases in the use of fertilizers are examined. Most arable root crops grown for sale are now receiving about as much fertilizer as can be justified, but more nitrogen is needed to grow full crops of cereals, and practically all crops grown for animal feeding are, on average, undermanured. Any major increase in the total amount of fertilizer used is likely to be achieved by better manuring of grassland.

2.8. Gasser, J. K. R. (1958). Use of deep-freezing in the preservation and preparation of fresh soil samples. *Nature, Lond.* **181**, 1334–1335.

Storage at −10° maintained the ammonium and nitrate contents of soils unchanged for periods up to 32 days. An increase in the mineral nitrogen

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content of soil occurred both during storage at 2° continuously, or at −10° and 2° alternately.

Prolonged deep-freezing or freezing and thawing up to 16 days did not affect the amount of mineral nitrogen formed on subsequent incubation of the fresh soil; air-drying after prolonged storage by either method, followed by re-wetting and incubation, resulted in less mineral nitrogen being formed during incubation than occurred when the unstored soil was used.

The physical condition of heavy soils was much improved by deep-freezing, and the resulting crumb structure facilitated sub-sampling, and also crushing and sieving after air-drying.

2.9. HEINTZE, S. G. (1957). Studies on soil manganese. *J. Soil Sci.* **8**, 287–300.

While results of extractions, performed in the presence of reducing agents, of mineral soils low in organic-matter content suggested that manganese higher oxides approaching the manganese dioxide type are present or formed by oxidation of added manganese, results obtained with other extractants lend support to the suggestion by Dion and Mann that hydrated manganic oxides may occur in such soils.

From the distribution of manganese in various extracts of alkaline organic soils with or without added manganese materials, it was concluded that no difficultly reducible higher oxides of manganese are present or formed. Some evidence was presented for the view that manganese of a higher valency form may remain in combination with the organic matter or may be retained in this manner after oxidation of added manganese.

Divalent manganese present as a complex of the organic matter of alkaline organic soils could be estimated by extraction with a monocalcium disodium versenate solution. It constituted 10–20 per cent of the total manganese content. Manganese added to such soils and not present as readily soluble manganese was recovered by this extractant shortly after application; manganese did not, however, remain in this form after some weeks' contact with soils.

The organic matter of various soluble organic-matter fractions migrated anionically over a wide pH range; that of lignin solutions remained at the iso-electric point. Manganese already present in soluble organic-matter fractions migrated anionically in contrast to manganese added and retained by such fractions that moved predominantly as a cation.

The oxidizable carbon or total nitrogen content of soluble organic-matter fractions was not closely related to the amounts of manganese retained by such fractions in a form that was non-dialysable against potassium chloride. Some evidence was obtained that different types of complexing groups may be present in water extracts subsequent to extraction by sodium chloride of an alkaline fen and of an acid raw-humus peat.

2.10. MATTINGLY, G. E. G., & WIDDOWSON, F. V. (1958). Uptake of phosphorus from ^{32}P-labelled superphosphate by field crops. Part II. Comparison of placed and broadcast applications to barley. *Plant & Soil*, **10**, 161–175.

Three field experiments with barley were carried out in successive years at Rothamsted to compare at different stages of growth, the uptake of phosphorus from ^{32}P-labelled superphosphate that was drilled with seed (5 lb. P/acre) or broadcast on the surface (10 lb. P/acre). The yields and total phosphorus uptakes obtained with equal amounts of radioactive and non-radioactive superphosphate were compared in 2 years in the field and in a single greenhouse experiment.

^{32}P-labelled superphosphate slightly reduced yields and total phosphorus uptakes in both field experiments, but the reductions in yield and uptake were seldom significant. In the greenhouse experiment similar yields and phosphorus uptakes were obtained with both radioactive and with non-radioactive superphosphate.

The percentage recovery of phosphate from superphosphate applied in seed drills was greater at all stages of growth in each year than from superphosphate broadcast on the seedbed. Recoveries at harvest in different years varied less from drilled superphosphate (10–15 per cent) than from broadcast superphosphate (5–12 per cent). At the rates of application tested in these

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experiments, uptakes of drilled and broadcast superphosphate take place independently throughout the growth of barley.

Drilled and broadcast superphosphate both increased the uptakes of soil phosphate by barley during the early stages of growth. In 1953 when the crop grew rapidly, the extra amounts of soil phosphate taken up 26 and 48 days after sowing were equal to 75 and 100 per cent of the amounts of fertilizer phosphorus taken up from drilled superphosphate and 64 and 23 per cent of the amounts of fertilizer phosphorus taken up from broadcast superphosphate. The increased uptakes of soil phosphorus that resulted from applying superphosphate were smaller in 1954 and 1955. In all years at harvest there was less soil phosphate in crops receiving superphosphate than in unmanured plants.

2.11. NEWMAN, A. C. D. (1958). The separation of fluoride ions from interfering anions and cations by anion exchange chromatography. *Analyt. chim. Acta*, **19**, 471–476.

Fluoride may be separated from phosphate and the anionic metal chelates of ethylenediaminetetraacetic acid (EDTA) by absorption on, and elution from, an anion-exchange column containing a strongly basic resin. This provides a simple and accurate method of removing interfering ions prior to the determination of fluoride by thorium nitrate titration, and is a satisfactory alternative to Willard–Winter distillation. A procedure is described for the determination of fluorine in rock phosphates and other materials soluble in alkaline EDTA solution.

2.12. NEWMAN, A. C. D. (1958). A spectrophotometric investigation of the reaction between fluoride and the complex of sodium quinalizarin sulphonate with aluminium. *Analyt. chim. acta*, **19**, 580–586.

A water-soluble sulphonate of quinalizarin (1 : 2 : 5 : 8-tetrahydroxyanthraquinone) was prepared and its molar extinction from 220–600 mμ recorded. The reaction of this derivative with aluminium was investigated spectrophotometrically and it was found that a complex was formed which exhibited two absorption peaks, one at 265 mμ and one at 495 mμ. The latter absorption peak was used to examine the influence of fluoride ions on the complex, and at pH 3·9 the absorption was markedly decreased by fluoride. A procedure was developed to use this bleaching to determine small quantities of fluoride, and it was applied to the estimation of fluoride in rock phosphates. This application showed, however, that the absorption of the reagent was dependent on pH to an extent which made the method accurate only when very close control of pH (±0·01) was possible. However, its simplicity enabled the method to be applied to the semi-quantitative analysis of large numbers of solutions per day.

2.13. SHAW, K. (1958). Studies on nitrogen and carbon transformations in soil. Thesis accepted for Ph.D. Degree of London University.

2.14. STOJKOVSKA, A. & COOKE, G. W. (1958). Micro-nutrients in fertilizers. *Chem. & Ind.* 1368.

The amounts of B, Mn, Cu, Zn, Co and Ni in samples of fertilizers and farmyard manure used in Yugoslavia and in England are stated. Most fertilizers make little contribution to the supplies of micro-nutrient in soils. A few fertilizers and also farmyard manure contain appreciable quantities of micro-nutrients, and where these materials are applied in sufficient quantities they may have some value in correcting micro-nutrient deficiencies.

2.15. WARREN, R. G. (1958). The residual effects of the manurial and cropping treatments in the Agdell Rotation Experiment. *Rep. Rothamst. exp. Sta. for 1957*, pp. 252–260.

A summary is given of the yields of crops grown in the Agdell experiment. Residues of nitrogen, phosphorus and potassium accumulated in the soils as a result of continuous treatment with fertilizers. The values of these residues for crops were measured after manuring was stopped in 1951, and the results of parallel laboratory investigations are reported.

Pedology Department

3.1. (Beavers, A. H.) & Stephen, I. (1958). Some features of the distribution of plant-opal in Illinois soils. *Soil Sci.* **86**, 1–5.

The presence, characteristics and distribution of opal in some Illinois soils are reported and its origin from the native grasses of the region demonstrated. The grains of opal are particularly abundant in the A-horizons. The value of the plant-opal as an "index mineral" for determining the presence and location of buried A-horizons in palaeosols is indicated.

3.2. Bloomfield, C. (1958). Mobilization of iron in podsol soils by aqueous leaf extracts. *Chem. & Ind.* 259–260.

3.3. Brown, G. & Stephen, I. (1959). A structural study of iddingsite from New South Wales, Australia. *Amer. Miner.* (In the press.)

The iddingsite (an alteration product of olivine) is polycrystalline and consists of goethite and a triphormic layer lattice silicate. In the alteration of olivine to iddingsite the original lattice of close-packed oxygens appears not to have been greatly disturbed and the changes have occurred by the movement of cations within small regions to form microcrystals of the alteration products. The parallel alignment of the components explains why it behaves optically as a single crystal.

3.4. Gower, J. C. & Rayner, J. H. (1958). Crystallographic programmes for a computer. *Brit. J. appl. Phys.* **9**, 446–447.

For summary see below, p. 272, 12.8.

3.5. Stephen, I. (1958). Recent advances in pedology—micromineralogy of soils. *Sci. Progr.* **46**, 317–322.

Soil Microbiology Department

General Papers

4.1. Meiklejohn, Jane (1958). Articles on: Nitrobacteriaceae; Methanomonadaceae; Soil Sulfur Microbial Cycle; Soil Phosphorus Microbial Cycle; Microbial Utilization of Soil Minerals. (In: *McGraw-Hill Encyclopedia of Science and Technology*.) New York: McGraw-Hill.)

4.2. Nutman, P. S. Origin and developmental physiology of root nodules. (In: *Handbuch der Pflanzenphysiologie*, **15**. Berlin: Springer-Verlag.) (In the press.)

4.3. Nutman, P. S. (1959). The physiology of nodule formation. (In: *Nutrition of the Legumes*, ed. E. G. Hallsworth.) London: Butterworth; 87–107.

The following stages in the infection of the root of clover are distinguished: (i) rhizosphere stimulation of bacterial multiplication; (ii) root hair curling; (iii) initiation of infection thread; (iv) infection thread growth; (v) activation of nodule site; (vi) nodule initiation. The influence of root secretion upon these stages in nodulation and the relation of nodulation to rooting habit and to the general physiology of the root are discussed.

4.4. Nutman, P. S. (1958). Sources of incompatibility affecting nitrogen fixation in legume symbiosis. *Symp. Soc. exp. Biol.* **13**. (In the press.)

The known defects in symbiotic nitrogen fixation in *Trifolium* are discussed in terms of the normal development of the root nodule, showing that incompatibility between bacterium and host can arise at different stages in the

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establishment of the symbiosis and that these can be distinguished phenotypically and by genetic analysis. The relation between symbiotic and free-nitrogen fixation is also discussed.

Research Papers

4.5. Jackson, R. M. (1958). Some aspects of soil fungistasis. *J. gen. Microbiol.* **19**, 390–401.

A series of fungi with varying degrees of sensitivity to fungistasis was selected as the result of agar disc and buried-slide tests with seventeen fungi and one soil. Six out of seven different soils exhibited a spectrum of inhibition of the test series of fungi similar to that of the first soil tested. The exception was a very acid raw humus soil which only inhibited the acid-sensitive fungus *Acrostalagmus cinnabarinus*. Fertilizer treatments of two series of plots at Rothamsted were found to affect soil fungistasis only through their influence on soil pH. Inhibitory effect decreased with increasing soil acidity, being absent from the most acid plot tested. The results of experiments in which three fungi were pre-incubated before exposure to the influence of soil suggest that spores are most sensitive to soil fungistasis at an early stage in germination.

4.6. Jackson, R. M. (1959). Soil fungistasis and the rhizosphere. (In: *Proc. Soil. Microbiol. Symp.*, Liverpool 1957.) (In the press.)

Experimental details are given of a study of the influence of seedling roots on inhibited fungal spores in soil using the buried-glass-plate and root-observation-cell techniques. In observation cells radish seedlings were more effective than tomato or lettuce in stimulating germination of chlamydospores of three species of *Fusarium* and conidia of *Gliocladium roseum* and *Acrostalagmus cinnabarinus*. After a short period of vegetative development, *G. roseum* and *P. marquandii* started to sporulate vigorously within the root zone of radish. The *Fusaria* were never observed to sporulate in the rhizosphere, but considerable vegetative development frequently occurred. Six monosaccharide sugars tested had a similar effect on soil fungistasis; fungistatic inhibition being partially counteracted by concentrations of 0·01 per cent and completely or nearly so by 1·0 per cent. Disaccharides were less effective and raffinose least effective of the sugars tested. Asparagine, alanine, leucine, Difco Casamino acids and Difco peptone were all found to be ineffective at concentrations up to 0·5 per cent.

4.7. Skinner, F. A. (1959). The decomposition of anionic surface active agents by soil bacteria. *Nature, Lond.* **183**, 548–549.

A species of *Pseudomonas* isolated from soil can utilize primary alkyl sulphates with alkyl radicals containing up to eighteen carbon atoms. The bacterium grows readily in dilute solutions of Teepol 530, a secondary alkyl sulphate, and causes a rapid increase in surface tension. The tendency of stronger Teepol solutions to foam is also suppressed, even though the surface tension rises very little during incubation. Detergent foaming additives of the alkylolamide type are also utilized, but tetrapropylene benzene sulphonate, the active constituent of some commercial detergents, is not attacked. Many soil micro-organisms can tolerate this persistent compound, but none have been found to decompose it.

4.8. Steenson, T. I. & Walker, N. (1958). Adaptive patterns in the bacterial oxidation of 2 : 4-dichloro- and 4-chloro-2-methyl-phenoxyacetic acid. *J. gen. Microbiol.* **18**, 692–697.

Organisms of a strain of *Flavobacterium peregrinum* and an *Achromobacter* strain, capable of decomposing 2 : 4-dichloro-phenoxyacetic acid (2 : 4-D) and 4-chloro-2-methyl phenoxyacetic acid (MCPA) respectively, have been obtained by growing cultures on peptone agar plates containing either 2 : 4-D or MCPA. Glucose did not prevent adaptation. Organisms of the *F. peregrinum* strain were adapted to oxidize 2 : 4-D when grown on peptone agar containing either MCPA or 2-chloro-4-methyl-phenoxyacetic acid; they

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did not decompose MCPA. The effects of some related compounds on adaptation to 2 : 4-D by these bacteria were examined. Growth of the *Achromobacter* strain on peptone agar containing either 2 : 4-dichlorophenol or 5-chloro-2-cresol gave organisms which were adapted to oxidize both 2 : 4-D and MCPA as well as the inducing compound.

Botany Department

General Papers

5.1. Humphries, E. C. (1958). Entry of nutrients into the plant and their movement within it. *Proc. Fertil. Soc. no.* 48, 1–36.

5.2. Thurston, J. M. (1958). The maximum recorded survival of weed seeds in soil. *Turf for Sport*, **3**, 3–5.

5.3. Watson, D. J. (1958). Factors limiting production. (In: *The Biological Productivity of Britain.* Ed. W. B. Yapp and D. J. Watson, pp. 25–32.) London: Institute of Biology.

Research Papers

5.4. Humphries, E. C. (1958). The effect of removal of the root-system of barley on the production of ears. *Ann. Bot. Lond. N.S.* **22**, 417–422.

Complete removal of roots of barley plants, grown in water culture, at a stage before the plants have attained their maximum shoot number, results in a significantly greater number of ears at harvest. If the roots are excised when shoot number is beginning to decline the number of ears is decreased. The cause of the phenomenon is not known, but it is suggested that it may be due to a temporary diversion of carbohydrate to the shoots when the roots are excised.

5.5. Humphries, E. C. (1958). Effect of gibberellic acid and kinetin on growth of the primary leaf of dwarf bean (*Phaseolus vulgaris*). *Nature, Lond.* **181**, 1081–1082.

Expansion of primary leaves was accelerated by treatment with gibberellic acid; but the final area attained was identical with that of leaves receiving no treatment. Kinetin (6-furfurylaminopurine), on the other hand, depressed the rate of leaf expansion—an effect which was overcome in the presence of gibberellic acid.

5.6. Humphries, E. C. (1958). The effects of gibberellic acid and kinetin on the growth of Majestic potato. *Ann. appl. Biol.* **46**, 346–351.

The effects of spraying potato plants (var. Majestic) with gibberellic acid and kinetin were investigated. Gibberellic acid increased both leaf area and dry-matter production over the short period of the experiment, but there were indications that this would not persist at maturity. Kinetin alone depressed leaf area and dry-matter production, but this did not occur in the presence of gibberellic acid. The mean net assimilation rate measured over a 2-week period was not significantly reduced by gibberellic acid.

5.7. Monteith, J. L. & (Owen, P. C.) (1958). A thermocouple method for measuring relative humidity in the range 95–100%. *J. sci. Instrum.* **35**, 443–446.

For summary see p. 236 above, no. 1.4.

5.8. Owen, P. C. (1958). The effects of short periods of water stress on the growth of sugar beet in pots. *New Phytol.* **57**, 318–325.

Sugar beet, broad beans and lettuce growing in soil in pots were subjected to repeated short periods of water stress up to a maximum pF of 4·0. In

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some experiments the leaf areas of such plants were lower than those of plants grown under conditions of minimum water stress, but there was no significant effect of water stress on dry-matter production or net assimilation rate. The loss of water per unit leaf area was not affected by the water regime, but the cumulative water loss from pot and plant over the experiments was greater under the wet regime, partly because the leaf area was greater. In pot-culture experiments, where the total amount of water within the root zone is relatively small, it is impossible to impose stress conditions above wilting point for long enough to produce detectable effects on growth. The results of water-stress experiments may depend as much on the duration and timing of the periods of stress as on the level of stress imposed.

5.9. OWEN, P. C. (1958). The growth of sugar beet under different water regimes. *J. agric. Sci.* **51**, 133–136.

In a small plot experiment in which the crop was protected from rain, the application of large amounts of water to keep the soil water stress to a minimum gave very large crop yields. One-fifth of this amount of water gave 80 per cent of the maximum yield. Small, frequent applications of water appeared to give higher yields than the same amount of water in one large application. Yield differences were due to differences in leaf area rather than in net assimilation rates.

5.10. THORNE, G. N. (1958). Factors affecting uptake of radio-active phosphorus by leaves and its translocation to other parts of the plant. *Ann. Bot. Lond. N.S.* **22**, 381–398.

The rate of uptake of ^{32}P from labelled NaH_2PO_4 solutions sprayed on to one leaf of swedes (*Brassica napus*) or French beans (*Phaseolus vulgaris*) was rapid during the first few hours and fell to zero after 4 days. ^{32}P was detected in the root after 3 hours and continued to move out of the treated leaf for at least 6 days after application. A larger fraction of the applied ^{32}P was absorbed from repeated than from a single spraying.

Swedes absorbed more ^{32}P from a single application to the lower surface than to the upper surface of the leaf. Doubling the concentration of the spray caused a small increase in the percentage of applied ^{32}P that was absorbed. Absorption by French-bean leaves decreased slightly when the area sprayed with a constant amount of ^{32}P was doubled, and decreased with increasing age of leaf. Increasing the phosphorus supply to the roots of swedes affected neither the initial rate nor the total amount of ^{32}P uptake by the leaves, but decreased the quantity of ^{32}P that was translocated out of the treated leaf.

Increasing the relative humidity of the air around the plants also increased ^{32}P uptake. Shading usually decreased uptake and always decreased translocation. Rewetting the leaf to which the ^{32}P had been applied, with water or sucrose solution, had variable effects. The significance of the results is discussed.

BOOK

5.11. BRENCHLEY, W. E. (revised by WARINGTON, K., 1958). *The Park Grass plots at Rothamsted 1856–1949.* [A revision of *Manuring of grassland for hay*, 1924.] Harpenden: Rothamsted Experimental Station.

Biochemistry Department

GENERAL PAPERS

6.1. PIRIE, N. W. (1958). World hunger as a biochemical problem. *J. Roy. Soc. Arts*, **104**, 511–528.

6.2. PIRIE, N. W. (1959). *Leaf proteins. Ann. Rev. Plant Physiol.* **10**.

6.3. PIRIE, N. W. (1958). Leaves as a source of human food. *Vegan*, **10**, 7–9.

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6.4. PIRIE, N. W. The properties of fragments of tobacco mosaic virus. *Proc. IV Int. Symp. Biochem.*, 1958. Symp. 7 preprint 7, 1–12.

6.5. PIRIE, N. W. Chairman's summing up to the 7th symposium. *Proc. IV Int. Symp. Biochem.*, 1958.

6.6. PIRIE, N. W. (1959). Some aspects of the origins of life considered in the light of the Moscow International Symposium. *Int. Coun. Sci. Unions Rev.* **1**.

6.7. PIRIE, N. W. (1958). The position of stereoisomerism in argument about the origins of life. *Trans. Bose Inst.*, J. C. Bose Memorial Vol. **22**, 111–120.

6.8. PIRIE, N. W. Contribution to the discussion on glutathione. *Biochem. Soc. Symp.* **16**. (In the press.)

RESEARCH PAPERS

6.9. CLARKE, A. J. & MANN, P. J. G. (1959). Plant enzyme reactions leading to the formation of heterocyclic compounds. 3. Plant amine oxidase and the formation of pyrrolidine and piperidine alkaloids. *Biochem. J.* **71**, 596–609.

The oxidation of 1 : 4-diaminobutane, 1 : 5-diaminopentane, 1 : 6-diaminohexane and 1 : 10-diaminodecane, catalysed by purified plant amine oxidase preparations in presence of catalase, took place without formation of CO_2. When these oxidations were carried out in presence of β-keto acids CO_2 was formed. The CO_2 outputs sometimes exceeded the O_2 uptakes and arose by decarboxylation of the β-keto acids. The rates of decarboxylation in such systems depended on the amine used as substrate. It was greatest with 1 : 4-diaminobutane and least with 1 : 10-diaminodecane. In manometric experiments evidence was obtained that the decarboxylations were due to stoicheiometric reactions between the β-keto acids and the oxidation products of the amines. The results of paper-chromatographic investigations suggested that the decarboxylations were dependent on condensation reactions between the unsaturated ring compounds, formed by the spontaneous cyclization of the products of oxidation of the amines, and the β-keto acids. This was established by the isolation of *nor*hygrine and *iso*pelletierine from reaction mixtures in which 1 : 4-diaminobutane and 1 : 5-diaminopentane, respectively, were oxidised in presence of acetoacetate. The possible significance of the results in relation to alkaloid biosynthesis is discussed.

6.10. HOLDEN, M. (1957). An investigation on polyphenolic compounds of the cacao leaf in connexion with a chemical method for detecting virus infection. *J. Sci. Fd Agric.* **10**, 553–561.

Polyphenolic substances in acid extracts of cacao leaves have been separated by paper partition chromatography. The substance which gives a red colour when cacao leaf extracts are heated with alkali, a reaction which has been used as the basis of a " colour-test " for detecting infection with swollen shoot virus, has the properties of a *leuco*-anthocyanin. The amount of red-producing *leuco*-anthocyanin varies with the total tannin content of the leaf. In addition to virus infection, other factors, such as age of leaf and variety of cacao, which affect the total tannin content also affect the *leuco*-anthocyanin content. The bearing of this on the applicability of the " colour-test " is discussed.

6.11. KENTEN, R. H. (1958). Manometric studies of bracken (*Pteridium aquilinum* (L.) Kuhn) thiaminase. *Biochem. J.* **69**, 439.

The transfer reaction of bracken thiaminase can lead to the production of H^+ ions. Under these conditions it is shown that the reaction can be studied manometrically in bicarbonate–carbon dioxide buffer. When aniline,

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piperidine, pyridine and trimethylamine are used as acceptor amines with thiamine in limiting amount, about 5–10 per cent of the thiamine may be lost in side reactions, but there is a reasonable agreement between the calculated and experimental carbon dioxide output. The effect on the rate of bracken thiaminase action of varying the concentration of thiamine and the concentration and type of acceptor amine has been studied.

The manometric method has been used to demonstrate that heteropyrithiamine, quinilino-thiamine, and possibly oxythiamine, are thiaminase substrates. The effect of several structural analogues of thiamine on bracken thiaminase has been studied, and it is shown that 3-(*o*-aminobenzyl)-4-methylthiazolium chloride is a powerful but non-competitive inhibitor.

Conditions are described under which the rate of evolution of carbon dioxide is directly proportional to the amount of bracken-thiaminase preparation present. It is suggested that the manometric method could be used for estimating thiaminase activity.

6.12. PIERPOINT, W. S. (1959). Mitochondrial preparations from the leaves of tobacco (*Nicotiana tabacum*). *Biochem. J.* **71**, 518–527.

A succinoxidase preparation was made from tobacco leaves by grinding them in a medium containing sucrose, tris buffer, phosphate, citrate and ethylenediamine tetraacetic acid, and then centrifuging them between 1,000 and 10,000 g. These preparations contained a third of the chlorophyll, 15 per cent of the total protein N and the bulk of the succinoxidase of the extract. The latter was inhibited by malonate and cyanide. The preparations oxidized most of the acids of the tricarboxylic acid cycle; co-factors such as diphosphopyridine dinucleotide, thiamine pyrophosphate and co-enzyme A stimulating some of these oxidations. The products formed during the oxidations of these acids were identified by paper chromatography as other acids of the tricarboxylic acid cycle.

6.13. PIRIE, N. W. (1959). The large-scale separation of fluids from fibrous pulps. *J. biochem. microbiol. Technol. & Engng*, **1**.

Most of the free fluid can generally be expressed from fibrous pulps in a few seconds at 50 lb./sq. in. if the layer of pulp is kept thinner than 1 inch after it has been pressed, and if the fluid is allowed to run away freely. The need for this time and the frictional properties of many pulps are serious obstacles to the design of any strictly continuous press. Roller presses do not allow enough time, screw expellers create too much friction, continuous centrifuges and some other arrangements are intricate and vulnerable.

An intermittent but automatic press which avoids these defects is described. In this the material on a perforated conveyor is pressed by a ram and then moved forward as the ram lifts. One such machine has already been made. An outline is given of the principles on which an improved design will depend.

Plant Pathology Department

GENERAL PAPERS AND REVIEWS

7.1. BAWDEN, F. C. (1958). Viruses and virus diseases (Amos Memorial Lecture). *Rep. E. Malling Res. Sta. for 1957*, 37–42.

7.2. BAWDEN, F. C. (1959). Physiology of virus diseases. *Ann. Rev. Plant Physiol.*

7.3. BAWDEN, F. C. (1959). Viruses. (In: *Vistas in Botany.*) London: Pergamon Press Ltd.

7.4. BAWDEN, F. C. (1959). The multiplication of plant viruses: the establishment and development of infection. (In: *Plant Pathology—Problems and Progress 1908–1958* (Golden Jubilee Meetings, American Phytopathological Society, Bloomington, August 1958.))

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7.5. BAWDEN, F. C. (1959). The multiplication of viruses. (In: *Plant Pathology—A Treatise on Basic Principles*, **2**.) New York: Academic Press, Inc.

7.6. BROADBENT, L. (1958). Insect vector behaviour and the spread of plant viruses in the field. (In: *Plant Pathology—Problems and Progress 1908–1958* (Golden Jubilee Meetings, American Phytopathological Society, Bloomington, August 1958).)

7.7. BROADBENT, L. (1958). Virus control depends on teamwork. *Farmers Weekly*, Supplement on Sugar Beet and Potatoes (16 May), 18–19.

7.8. BROADBENT, L. (1958). Control of virus spread in potato crops. *Outlook Agric.* **2**, 13–15.

7.9. BROADBENT, L. (1959). Dispersal of inoculum by insects and other animals, including man. (In.: *Plant Pathology—A Treatise on Basic Principles*, **3**.) New York: Academic Press, Inc.

7.10. BROADBENT, L. & MARTINI, C. (1958). The spread of plant viruses. *Advanc. Virus Res.* **6**, 93–135.

7.11. BUXTON, E. W. (1959). Mechanisms of variation in *Fusarium oxysporum* in relation to host–parasite interactions. (In: *Plant Pathology—Problems and Progress 1908–1958* (Golden Jubilee Meetings, American Phytopathological Society, Bloomington, August 1958).)

7.12. BUXTON, E. W. (1959). Variability in plant pathogens as a result of heterokaryosis, saltation and adaptation. *Plant Pathology—A Treatise on Basic Principles*, **2**. New York: Academic Press, Inc.

7.13. HARRISON, B. D. (1958). Mechanism of transmission of potato leaf roll virus by *Myzus persicae* Sulz. *7th Int. Congr. Microbiol., Stockholm, Abstracts*. pp. 258–259.

7.14. HARRISON, B. D. (1959). The multiplication of viruses in plants. (In: *Virus Growth and Variation* (9th Symp. Soc. gen. Microbiol.), 34–60.) Cambridge: University Press.

7.15. HIRST, J. M. (1958). New methods for studying plant disease epidemics. *Outlook Agric.* **2**, 16–26.

7.16. HIRST, J. M. (1958). Apple scab at Wisbech. Achievements and problems after five years research. *Grower & Prepacker*, 15 March, 681–683; 22 March, 741–743.

7.17. HIRST, J. M. (1959). Spore liberation and dispersal. (In: *Plant Pathology—Problems and Progress 1908–1958*) (Golden Jubilee Meetings, American Phytopathological Society, Bloomington, August 1958).)

7.18. HULL, R. (1958). Sugar Beet Yellows. The search for control. *Agriculture, Lond.* **65**, 62–65.

7.19. KASSANIS, B. (1958). Viruskrankheiten bei Nelken und ihre Bekämpfung. *Gartenwelt*, **58**, 362–363.

7.20. WATSON, MARION A. (1958). The significance of some recent work on aphid and hopper transmitted viruses (Linnean Society Lecture).

7.21. WATSON, MARION A. (1959). Cereal virus diseases in Great Britain. *N.A.A.S. Quart. Rev.*

RESEARCH PAPERS

7.22. BADAMI, R. S. (1958). Changes in the transmissibility by aphids of a strain of cucumber mosaic virus. *Ann. appl. Biol.* **46**, 554–562.

A strain of cucumber mosaic virus isolated from a spinach plant in 1946 was readily transmitted by *Myzus persicae* until 1955 when it lost this property, although it was still being propagated in conditions in which other strains remained transmissible. *Myzus circumflexus* also transmitted other strains but not this one. It was transmitted as readily as other strains by *Aphis gossypii* and *Myzus ascolonicus*. *M. ascolonicus* transmitted less frequently than *A. gossypii*. Transmission of the spinach strain by other aphids did not make it transmissible by *M. persicae*; nor did propagation in different plant species or several passages through spinach. In 1955 the spinach strain was occasionally transmitted by *M. persicae*, but the cultures isolated in this way were no more readily transmissible by the aphid than was the bulk culture maintained by manual inoculation of sap, and after a few weeks all cultures ceased to be transmitted by *M. persicae*.

7.23. BADAMI, R. S. (1959). Some effects of changing temperature and of virus inhibitors on infection by cucumber mosaic virus. *Ann. appl. Biol.* **47**, 78–89.

Whereas the spinach strain of cucumber mosaic virus fails to multiply and cause symptoms in tobacco plants kept above 30°, the yellow strain infects at 36° and causes more severe symptoms than at 20°. Increasing the temperature up to 28° increases the initial rate at which the spinach strain multiplies, but the virus later reaches much higher concentrations in leaves at lower temperatures, presumably because it is rapidly inactivated at 28°. Exposing inoculated plants to 36° for 6 hours decreases the number of infections by the spinach strain when the exposure starts within 6 hours of inoculation, but not afterwards.

Pancreatic ribonuclease inhibits infections by strains of cucumber mosaic virus; inhibition is greatest when the enzyme is present in the inoculum, and when applied to inoculated leaves its effect decreases rapidly with increasing time after inoculation.

Infection by and the multiplication of strains of cucumber mosaic virus in tobacco are only slightly affected by thiouracil and greatly by azaguanine, whereas strains of tobacco mosaic virus are inhibited much more by thiouracil than by azaguanine. Like tobacco mosaic virus, cucumber mosaic virus multiplies more when inoculated leaves are floated in nutrient solutions than in water, but unlike tobacco mosaic virus, its multiplication is not inhibited by thiouracil more in nutrient solutions than in water.

7.24. BADAMI, R. S. & KASSANIS, B. Some properties of three viruses isolated from a diseased plant of *Solanum jasminoides* Paxt. from India. *Ann. appl. Biol.* (In the press.)

Three mechanically transmissible viruses were isolated from a diseased *Solanum jasminoides* plant obtained from India. One is a strain of potato virus Y, which in some potato varieties produces symptoms resembling those caused by potato virus C, but unlike potato virus C, it is readily transmitted by *Myzus persicae*. The second, named tobacco wilt virus, is also transmitted by *M. persicae* but much less readily, whereas the third, named datura necrosis virus, is not. All three have a wide host range, but neither tobacco wilt nor datura necrosis viruses infect potato plants. All three have long flexuous particles and similar general properties.

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Simultaneous infection with datura necrosis virus usually decreases the concentration reached by potato virus Y in tobacco plants but not in *Nicotiana glutinosa*.

7.25. Banks, C. J. & Nixon, H. L. (1958). Effects of the ant, *Lasius niger* L., on the feeding and excretion of the bean Aphid, *Aphis fabae* Scop. *J. exp. Biol.* **35**, 703–711.

For summary see below, no. 10.4.

7.26. Bawden, F. C. (1958). Reversible changes in strains of tobacco mosaic virus from leguminous plants. *J. gen. Microbiol.* **18**, 751–766.

Strains of tobacco mosaic virus (TMV) obtained from systemically infected leguminous plants in Nigeria and India changed their properties greatly when propagated in different hosts. From systemically infected tobacco, they closely resemble type TMV and share many antigens with it, but from systemically infected French bean, they differ from it by at least as much as any previously described strains. The different forms of the viruses share few antigens, have different amino-acid constitutions, electrophoretic behaviour and resistance to inactivation by ultra-violet radiation, and they produce different kinds of local lesion in *Nicotiana glutinosa*. Isolates derived from single local lesions behave like the original bulk cultures, and as the changes are also reversible, they seem unlikely to occur simply because different hosts select different strains from existing mixtures. The electrophoretic patterns, particularly of preparations from beans, show that infected plants contain more than one anomalous product; both forms of the viruses may be produced in all hosts, but there is no evidence that sap from systemically infected beans contains the tobacco forms in amounts needed to cause infection. The change after transfer to a new host apparently occurs because mutants produced in that host are favoured over the infecting form because they move more readily and become systemic. The bean forms multiply more extensively in tobacco at above 30° than at 20°, and above 30° seem not to produce forms that give a systemic mosaic; many tobacco plants at 20° develop only local lesions, and systemic infection, indicating the occurrence of the tobacco forms, happens more often in young seedlings than when mature plants are inoculated.

7.27. Bawden, F. C. & Kleczkowski, A. Some properties of decomposition products of potato virus X. *Virology*. (In the press.)

Its small surface potential probably accounts for the tendency of potato virus X (PVX) to become insoluble during purification. The protein produced by splitting the virus with alkali (about pH 10) has a higher surface potential, electrophoretic mobility in *M*/15 pH 7 phosphate buffer of −0·15 compared with −0·04 μ/second/V/cm. for the virus. The nucleic acid, mobility −1·7, is not infective when it is separated electrophoretically from alkali-split virus. The protein, but not the nucleic acid, precipitates with PVX anti serum. Material with the same electrophoretic mobility as protein produced by splitting the virus with alkali is sometimes detectable in sap from infected plants. Treatments that aggregate protein fragments from tobacco mosaic virus into virus-like rods produce amorphous precipitates of PVX protein that do not redissolve; this difference may reflect the different ways in which surface charges are distributed on the protein from the two viruses. The nucleic acid seems not to contribute to the surface potential of either virus. Disrupting PVX with phenol gives water-soluble material consisting predominantly of nucleic acid; freshly made preparations have some infectivity, which is not conferred by residual intact virus particles.

7.28. Broadbent, L., Burt, P. E. & Heathcote, G. D. (1958). Insecticidal control of potato virus spread. *Proc. 3rd Conf. Potato Virus Diseases, Lisse-Wageningen.*

Replicated trials were done during the years 1955 and 1956 to find out if fewer than the eight sprays of DDT emulsion previously used to limit the spread of leaf roll and Y viruses in Majestic potato crops would be effective, and if low-volume application was as effective as high.

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Although aphid control was relatively poor during the hot weather of late summer in 1955, virus control in that year was good. The factors of increase in disease, showing in 1956, from the 0·8 per cent deliberately planted in 1955, were for leaf roll: sprayed eight times, none; six times, 1·5; four times, 2·1; twice, 3·7; and unsprayed 15·3. Comparable figures for rugose mosaic were 6·3, 5·2, 7·3, 9·0 and unsprayed 13·6.

Both aphid control and control of virus spread were good in 1956. Plants were sprayed four or six times at high or low volume. There were no statistically significant differences between treatments: the factors of increase in leaf roll, from the 0·8 per cent planted, averaged 1·6 for sprayed, 7·4 for unsprayed plots, and for rugose mosaic 2·1 for sprayed, 4·9 for unsprayed plots.

The efficiency of the DDT deposits increased as the plant growth-rate decreased. Each year there was an increase in yield in the sprayed plots in comparison with the unsprayed, which roughly equalled the loss in yield caused by the machinery, which damaged the haulms.

An unreplicated trial with King Edward potatoes, on a commercial farm in Essex, tested the control of virus spread achieved by spraying rogued or unrogued areas fortnightly six times with DDT emulsion or endrin. The incidence of virus disease in the untreated area after 3 years was 27 per cent leaf roll and 0·6 per cent rugose mosaic, so this stock was rejected. In the DDT-sprayed area, after 4 years, the incidence of leaf roll was 4·5 per cent, but only 1·5 per cent where this had been rogued; in the endrin-sprayed area there was 7·8 per cent, and 2·9 per cent where rogued. The trial was discontinued after 4 years because virus Y was introduced by aphids during the third year, infecting between 5 and 14 per cent of the tubers in the different sprayed areas.

7.29. BROADBENT, L. & HEATHCOTE, G. D. (1958). Properties and host range of turnip crinkle, rosette and yellow mosaic viruses. *Ann. appl. Biol.* **46**, 585–592.

Three isolates of turnip yellow mosaic virus and two other flea-beetle transmitted viruses, turnip crinkle and turnip rosette, have many similar properties: thermal inactivation end-point between 80° and 90° C.; dilution end-point greater than 10^{-4}; longevity *in vitro* at about 20° C. at least 30 days. All were transmitted by mechanical inoculation to a wide range of cruciferous host plants, including many weeds. Turnip yellow mosaic virus infected only *Reseda odorata* outside the *Cruciferae*, whereas rosette virus infected a few and crinkle virus many non-cruciferous hosts.

7.30. BUXTON, E. W. (1958). A change of pathogenic race in *Fusarium oxysporum* f. *pisi* induced by root exudate from a resistant host. *Nature, Lond.* **181**, 1222–1224.

Retaining spores of *Fusarium oxysporum* f. *pisi* physiologic race 1 for 14 days in exudates from roots of pea variety Wilt-Resistant Alaska changed their pathogenicity. They became able to act like race 2, in that they wilted this pea variety, having previously been unable to do so. The same result was obtained by repeatedly transferring the spores of race 1 through a series of increasing concentrations of the same root exudate. The same treatments also impaired the ability of race 1 to wilt the susceptible pea variety Onward, for it produced only 73 per cent wilt against the usual 100 per cent by untreated spores. Seven successive inoculations and re-inoculations of the treated spores to variety Wilt-Resistant Alaska failed to change the host-induced increase in pathogenicity.

Changes of this kind, in which physiological activity is altered by an inducing substrate, are common among bacteria, and are generally described as adaptation. It is not known whether the change in pathogenicity described here is a result of selection by the inducing substrate (root exudate) from a resistant plant of randomly occurring mutants, or of the increase by " enzymatic adaptation " of a latent ability to detoxify the exudates from roots of resistant hosts. Mechanisms of this kind, leading to increased host range in a pathogen, whether temporary or permanent, may underly the outbreaks of disease that frequently occur among hitherto resistant host varieties.

7.31. BUXTON, E. W., PERRY, D. A. (DOLING, D. A. & REYNOLDS, J. D.) The resistance of pea varieties to Fusarium wilt. *Plant Path.* (In the press.)

Tests for resistance to wilt, caused by the fungus *Fusarium oxysporum* f. *pisi*, were made with ninety different pea varieties that are in commercial use in Britain. Replicated plots of each variety, together with control strips of the highly susceptible variety Onward, were sown in wilt-infested fields at Rayne, Essex, and at Yaxley, Peterborough.

Forty-nine per cent of the varieties proved to be wilt-resistant, and nineteen of the susceptible varieties contained a few plants that showed some degree of resistance, resulting from genetic segregation in the parent stocks. Together with observations made in previous years, the reaction to wilt of 143 varieties in this country is now known, and about half are resistant. Unfortunately, pea varieties that are the most popular and in greatest demand are susceptible. There was no correlation between resistance and any morphological characteristic of pea varieties, nor was any particular group of peas, e.g., canners, dried peas, etc., especially resistant.

Comparison with the results of similar field tests reported from Holland and New Zealand show that some varieties have a different reaction to wilt in each locality, probably reflecting an uneven distribution of different pathogenic races of the fungus. In our test areas, races 1 and 3 were prevalent, but there was no evidence of race 2.

Attempts to speed up the classification of pea varieties for wilt-resistance by using artificial inoculation techniques in the glasshouse showed that the only reliable methods can come from using soil from infested fields.

Further progress in combating pea wilt could best be made by breeding resistance into the susceptible commercially popular varieties.

7.32. CHESSIN, M. (1958). Light quality and photoreactivation of plants and viruses. *Ann. appl. Biol.* **46**, 388–392.

Visible light of different spectral regions was tested for its ability to reverse three effects of ultra-violet radiation, namely, injury (glazing) of French-bean leaves, increased resistance of French-bean leaves to infection by Rothamsted tobacco necrosis virus and inactivation of potato virus X. The different spectral regions were obtained with colorimetric filters and the filtered and unfiltered light from fluorescent tubes; all three effects were reversed only by regions of wavelengths shorter than 4,700 Å. Thirty minutes of illumination at 300–380 f.c. gave substantial photoreactivation, but irradiated potato virus X did not become affected by visible light until 30 minutes after tobacco leaves were inoculated.

7.33. GLYNNE, MARY D. (1959). Effect of potash on powdery mildew in wheat. *Plant Path.* **8**, 15–16.

The incidence of powdery mildew *Erysiphe graminis* on wheat grown on certain Broadbalk plots was measured by estimating the percentage area of the top two leaves covered by mildew pustules. The disease was most severe on plots receiving nitrogen and phosphate but no potash; was more severe in the first than the third crop after fallow, and was least in plots receiving potash.

7.34. GLYNNE, MARY D. & SLOPE, D. B. (1959). Effects of previous wheat crops, seed-rate and nitrogen on eyespot, take-all, weeds and yields of two varieties of winter wheat. *Ann. appl. Biol.* **47.**

In a replicated field experiment mean yields of wheat from plots that, in the preceding 2 years, had carried oats, beans or potatoes were 39·2 and 42·6 cwt./acre in 1954 for Holdfast and Cappelle respectively; 42·8 and 55·8 in 1955 and 34·9 and 49·6 in 1956. Previous wheat crops had more effect than any other treatment in increasing the incidence of eyespot, take-all and weeds and in decreasing the number of ears per unit area and the yield of grain. In 1956 on plots carrying the first, second and third successive wheat crops the percentage of straws with eyespot were respectively 12, 54 and 42 and with take-all 0·1, 1 and 16. Cappelle was less severely infected by eyespot than Holdfast. The second and third successive wheat crops yielded an average of 23·3 cwt./acre less than the first wheat crop. Cappelle consistently yielded more than Holdfast, the mean difference being 13·8 cwt./acre after potatoes

but only 3·8 cwt./acre after two wheat crops. The higher seed-rate gave an average increase in grain yield of 3·3 cwt./acre; but where eyespot and take-all were both severe, the lower seed-rate yielded as much total and more dressed grain than the higher. Wheat given a spring top dressing of 6 cwt./acre " Nitro-chalk " yielded an average of 4 cwt./acre more grain than wheat given 3 cwt./acre.

7.35. GREGORY, P. H. & STEDMAN, O. J. (1958). Spore dispersal in *Ophiobolus graminis* and other fungi of cereal foot rots. *Trans. Brit. mycol. Soc.* **41**, 449–456.

During October 1953 air was sampled with a Hirst (1952) automatic volumetric spore trap at a height of 0·5 m. above the stubble of a wheat crop bearing fructifications of *Ophiobolus graminis*, *Cercosporella herpotrichoides* and *Fusarium culmorum*. Exposed slides were scanned under the microscope in positions corresponding to 2-hourly intervals, to estimate the concentrations of various spore types. Ascospores of *O. graminis* were never caught on rainless days; nor after rain of less than 0·01 inch. They were caught within an hour of 0·01 inch or more rain, and attained a maximum concentration of 3,700/cu. m. of air within 2 hours of rain of 0·05 inch. Wind-tunnel tests showed that the peak rate of liberation occurred within 45 minutes of wetting. All mature ascospores seemed to be discharged during 4 hours of rain, but a few dry days sufficed for another batch to mature. *C. herpotrichoides* behaved differently: a few conidia occurred after a trace of rain, and more rain did not increase their numbers; their maximum concentration was only one-tenth of *O. graminis*. Concentrations of coloured basidiospores were constant, regardless of weather and time of day, and *Cladosporium* was more common by day than by night. No macroconidia of *Fusarium* were detected.

7.36. HEATHCOTE, G. D. & WARD, J. (1958). The preference shown by *Myzus persicae* (Sulz.) for *Brassica* plants sprayed with wetting agents. *Bull. ent. Res.* **49**, 235–237.

For summary see below p. 260, no. 9.9.

7.37. HIRST, J. M. & SALT, G. A. *Oospora pustulans* Owen and Wakef., as a parasite of potato root systems. *Trans. Brit. mycol. Soc.* (In the press.)

A fungus isolated from brown lesions in the cortex of root systems of Majestic potatoes at Rothamsted in 1951 was identical morphologically with *Oospora pustulans*, the cause of skin-spot disease of tubers. The pathogenicity of *O. pustulans* from tubers for root systems of potato and tomato was demonstrated. Tuber yield was not greatly affected despite severe damage to the roots, and the chief importance of root infection may be to provide sources of infection for progeny tubers or subsequent potato crops.

The infection of root systems, prevalent at Rothamsted each year, does not obviously depend on previous potato cropping, or on the presence of macroscopic skin-spot symptoms on the seed tubers. Observations suggest that eye infections, which may not be detected by macroscopic examination, are common and that soil-borne fungus is probably less important in leading to outbreaks of skin-spot than fungus on the seed tubers. Test with tomato seedlings should help to determine how long *O. pustulans* survives in soil.

7.38. KASSANIS, B. & SLYKHUIS, J. T. Some properties of barley stripe mosaic virus. *Ann. appl. Biol.* (In the press.)

Barley varieties differed greatly in their reactions to infection with barley stripe mosaic virus (BSMV) obtained from the variety Gloire du Velay growing in Cambridgeshire from seed imported from France. *Lolium multiflora* Lam. previously considered immune, proved susceptible, as did *Beta vulgaris* L. and *Chenopodium amaranticolor* Corte & Reyn., which gave only local lesions, and *Spinacea oleracea* L., which became systemically infected.

Heating at 65° C. for 10 minutes destroyed the infectivity and serological activity of BSMV. Sap was still infective after 32 days at 20° C., but lost its infectivity and half of its serological activity in 3 days at −20° C.; adding sugar to the sap prevented inactivation by freezing. The virus content of inoculated barley leaves increased most rapidly in plants kept at 24° to 28° C.

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At 24° C. increase was most rapid during the first 5 days, and the maximum virus concentration was reached about 10 days after inoculation. The highest infection end-point of sap was 1/2048, when the precipitation end-point with virus antisera was 1/256, and sap contained 10^{13} virus particles/ml.; the ratio of infectivity to serological activity and to number of virus particles is much smaller than with tobacco mosaic virus.

The rod-shaped particles are about 20 mμ wide and, in fresh sap, most are between 135 and 175 mμ long. Various treatments, especially heating to 50° C., cause the particles to aggregate linearly. Preparations partially purified by alternate cycles of low- and high-speed centrifugation and by precipitation with ammonium sulphate contain from 0·35 to 0·53 per cent P, 12·3 to 13·2 per cent N and 6·2 to 10·2 per cent carbohydrate. Such preparations are insoluble in water but dissolve in borate buffer at pH 7·5; they inactivate below pH 4·5.

7.39. MACFARLANE, I. (1958). A solution-culture technique for obtaining root-hair, or primary, infection by *Plasmodiophora brassicae*. *J. gen. Microbiol.* **18**, 720–732.

Primary infections were obtained by growing cabbage seedlings in a modified Hoagland's solution in which resting spores of *Plasmodiophora brassicae* Woron. were suspended. Seeds were germinated on filter-paper wet with tap water, and after 2 days the plants were transferred to small glass tubes bent in the form of a shallow U or to small vials containing solution and spores. Zoosporangia were formed after several days growth at 25° in the dark. They were stained in acetocarmine. A roughly linear relationship was found between the logarithm of number of infections/root and the logarithm of spore concentration in the medium. Numbers of infections were usually greater at $\frac{1}{5}$ or $\frac{1}{25}$ dilution of the culture solution than at the standard concentration, but were very much fewer or none in more dilute $\frac{1}{125}$ or more concentrated ($\times 5$) solutions. The concentration which permitted maximal infection tended to vary from one experiment to another. Infection was not affected by changing from pH 5 to 6, but was greatly decreased at pH 8.

7.40. SALT, G. A. (1959). Effects of nitrogenous fertilizer applied at different dates on take-all, eyespot and yield of winter wheat grown on light sandy loam. (Field experiments 1954, 1955, 1956.) *Ann. appl. Biol.* (In the press.)

In a replicated field experiment on light, sandy loam at Woburn, where winter wheat is a very uncertain crop, Cappelle and Holdfast grown after potatoes with dung yielded 50 and 41 cwt./acre of grain respectively when given 6 cwt./acre of "Nitro-chalk" in April, compared with 19 and 20 cwt./acre when unfertilized. The same fertilized plots yielded 29 and 19 cwt./acre respectively in the second, and 25 and 17 cwt./acre respectively in the third year on the same land, whereas unfertilized plots of both varieties yielded only 9 cwt. and 5 cwt./acre. The decrease in mean yield from 27 cwt./acre in the first, to 15 and 10 cwt./acre in the second and third crops was associated with a decrease in ear number from 16·7 to 14·6 and 12·2 respectively, and with a striking decrease in weight of grain per ear, caused partly by a large increase in the proportion of small grains. Eyespot (*Cercosporella herpotrichoides* Fron.), although present each year, did not become prevalent; an increase in the percentage straws affected by take-all (*Ophiobolus graminis* Sacc.) from 9 to 15 and 26 per cent respectively, and a severe increase in weed infestation (*Agrostis gigantea*) appeared to be the main factors reducing yield.

"Nitro-chalk" applied in April yielded most grain every year, and wheat fertilized at this time had less eyespot and take-all than that fertilized in March. Fertilizer applied in May increased weed growth, failed to decrease take-all and yielded fewer ears, less grain and a higher proportion of tail corn than did earlier applications.

7.41. SALT, G. A. (1959). Eyespot of wheat in ley–arable rotation experiments at Rothamsted (1952–1958). *Plant Path.* **8.**

The incidence of soil-borne diseases in winter wheat (var. Yeoman), under different ley–arable rotations was compared in the ley–arable rotation experiments at Rothamsted, where the arable sequence wheat–potatoes–barley

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follows 3 years of grazed ley, cut grass, lucerne and the arable crops hay–potatoes–barley (later oats). In the 4 years 1952–55 eyespot (*Cercosporella herpotrichoides*) was prevalent in wheat after arable crops but not after any of the leys. The percentage of infected straws on Highfield (old pasture) and Fosters (old arable land) ranged from 6·3 and 6·4 to 43·2 and 90·3 per cent respectively after arable crops and from 0·2 and 1·2 to 4·2 and 14·7 per cent respectively after the leys. Oats, a much less susceptible crop, was substituted for barley in 1955, and consequently in the last 3 years there has been very little eyespot in any of the four rotations.

There was take-all (*Ophiobolus graminis*) on a few wheat straws after barley in one year, and none after grass or lucerne. Sharp eyespot lesions caused by *Rhizoctonia* (*Corticium*) *solani* occurred each year, and the percentage of infected straws, similar in all the rotations, ranged from 0·5 to 15·7 per cent in different years.

7.42. Slykhuis, J. T. & Watson, Marion A. 1958. Striate mosaic of cereals in Europe and its transmission by *Delphacodes pellucida* (Fab.). *Ann. appl. Biol.* **46**, 542–553.

A virus disease that resembles wheat striate mosaic was found affecting up to 5 per cent of the plants in English wheat fields in 1956. Symptoms on wheat included fine chlorotic striae, followed by stunting, general chlorosis and death of plants. Other hosts included oats, barley, rye, perennial ryegrass and Italian ryegrass.

The virus was transmitted by *Delphacodes pellucida* (Fabricius) (Homoptera, Araeopidae). A few of the insects were already infective when caught in the field. The percentage of infective individuals was increased by feeding the insects for 24 hours or longer on diseased plants, and up to 56 per cent became infective after feeding on diseased plants for 3 days. Non-infective insects were unable to transmit the virus until from 8 to 36 days after they first fed on diseased plants, but they frequently remained infective for the remainder of their lives, up to 10 weeks after feeding on a diseased plant. Infective insects seldom transmitted the virus during test feeds as short as 30 minutes. When fed for 1 or more days on each test plant some insects infected many plants in succession, others seldom infected test plants even if they fed as long as 7 days on each. The virus was transmitted through the eggs to as many as 88 per cent of the progeny of infective females, and to some of the progeny of a few females that had failed to infect wheat test plants.

Nematology Department

General Papers

8.1. Doncaster, C. C. (1959). High-speed flash photography of soil animals. (In: *Research methods in soil zoology*. Ed. P. W. Murphy.) London: Butterworth.

8.2. Doncaster, C. C. (1959). Cinematography of soil animals. (In: *Research methods in soil zoology*. Ed. P. W. Murphy.) London: Butterworth.

8.3. Fenwick, D. W. (1959). The genus *Heterodera*. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture, Tech. Bull. No. 7.) London: H.M.S.O.

8.4. Fenwick, D. W. (1959). Estimation of soil populations: principles and techniques. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7.) London: H.M.S.O.

8.5. Fenwick, D. W. (1959). Root diffusates and the hatching process in *Heterodera* spp. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7.) London: H.M.S.O.

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8.6. FRANKLIN, M. T. (1959). Root-knot nematodes, *Meloidogyne* spp. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7.) London: H.M.S.O.

8.7. FRANKLIN, M. T. (1959). Plant parasitic nematodes of the genus *Aphelenchoides* Fischer 1894. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture, Tech. Bull. No. 7.) London: H.M.S.O.

8.8. GOODEY, J. B. (1959). Preparation of nematodes for microscopic examination. (In: *Research methods in soil zoology*. Ed. P. W. Murphy.) London: Butterworth.

8.9. HESLING, J. J. (1959). The identification of *Heterodera* cysts. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7.) London: H.M.S.O.

8.10. JONES, F. G. W. (1957). Principles of population estimation. (In: *Proceedings of the S.19 Workshop in Phytonematology* Ed. E. J. Cairns. Univ. Tennessee. Popul. 1–11.)

8.11. JONES, F. G. W. (1957). Heterodera: life history, trends, host ranges, ecology, population studies, root diffusates. (In: *Proceedings of the S.19 Workshop in Phytonematology*. Ed. E. J. Cairns, Univ. of Tennessee. Heter. 1–13.)

8.12. JONES, F. G. W. (1957). Breeding and resistance to potato root eelworm, *Heterodera rostochiensis*, Woll. (In: *Proceedings of the S.19 Workshop in Phytonematology*. Ed. E. J. Cairns. Univ. Tennessee. Res. (Heter.): 1–17.)

8.13. JONES, F. G. W. (1957). Entomology and Nematology in the School of Agriculture, 1899–1956. *Mem. Camb. Sch. Agric.* **29**, 5–11.

8.14. JONES, F. G. W. (1958). Aspects of nematology in Great Britain. *Agric. Rev. Lond.* **3**, 8–19.

8.15. JONES, F. G. W. (1959). Ecological relationships of nematodes. (In: *Golden Jubilee Volume, American Phytopathological Society*.) (In the press.)

8.16. JONES, F. G. W. (1959). An introduction to plant nematology. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7.) London: H.M.S.O.

8.17. JONES, F. G. W. (1959). Beet eelworm and other root eelworms. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7). London: H.M.S.O.

8.18. MURPHY, P. W. & DONCASTER, C. C. (1959). A culture method and accessory techniques for soil micro-arthropods. (In: *Research methods in soil zoology*. Ed. by P. W. Murphy.) London: Butterworth.

8.19. WALLACE, H. R. (1958). The control of eelworms. *Diamond Fields Advertiser* (Kimberley, S. Africa.)

8.20. WALLACE, H. R. (1959). A study of the movement of eelworms in relation to some physical properties of soil. (In: *Research methods in soil zoology*. Ed. P. W. Murphy.) London: Butterworth.

8.21. WALLACE, H. R. (1959). The influence of soil conditions on larval emergence and movement. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No 7.) London: H.M.S.O.

8.22. WIDDOWSON, E. (1959). The conduct of hatching tests. (In: *Plant nematology*. Ed. J. F. Southey. Ministry of Agriculture Tech. Bull. No. 7.) London: H.M.S.O.

8.23. WIDDOWSON, E. (1959). Techniques for culturing *H. rostochiensis* Woll. in excised tomato roots. (In: *Research methods in soil zoology*. Ed. by P. W. Murphy.) London, Butterworth.

8.24. WIDDOWSON, E. (1959). The estimation of soil populations of the potato root eelworm. (In: *Research methods in soil zoology*. Ed. by P. W. Murphy.) London, Butterworth.

8.25. WINSLOW, R. D. (1958). Eelworm control. Some aspects of past and present research. *Agriculture, Lond.* **65**, 66–69.

RESEARCH PAPERS

8.26. FENWICK, D. W. & WIDDOWSON, E. (1958). The conduct of hatching tests on the potato root eelworm *H. rostochiensis*. *J. Helminth.* **32**, 125–134.

Methods for the collection and the preliminary assay of both cysts and diffusate for hatching experiments are set out. The general principles of the hatching-test technique are examined and show how experiments can be designed to give predetermined levels of accuracy. The interpretation of the results of a test falls into two parts, the estimation of the activity of the samples under tests and the analysis of the data to verify that the levels of accuracy obtained in the preliminary assays still apply.

8.27. GOODEY, J. B. (1958). *Paraphelenchus myceliopthorus* n.sp. (Nematoda: Aphelenchidae). *Nematologica*, **3**, 1–5.

Paraphelenchus myceliopthorus n.sp. is described and figured. The nematode attacks the mycelium in compost of cultivated mushroom beds. The excretory duct joins the pore to a ventral uninucleate cell. [Further examination shows that the duct continues in the lateral field beyond the cell.] The species is characterized by the pattern of the papillae on the male tail and the absence of a mucron on the female tail.

8.28. GOODEY, J. B. (1958). *Ditylenchus myceliophagus* n.sp. (Nematoda: Tylenchidae). *Nematologica*, **3**, 91–96.

Ditylenchus myceliophagus n.sp., which destroys mushroom mycelium, is described and figured. It differs morphologically from its nearest relative *D. destructor* in the broader finger-like tails of both sexes, in the shape of the spicules and the shorter post-vulval sac.

8.29. GOODEY, J. B. (1958). *Sphaeronema minutissimum* n.sp. (Sphaeronematinae: Tylenchulidae). *Nematologica*, **3**, 169–172.

Sphaeronema minutissimum n.sp. is described and figured. Females and larvae were found on the roots of *Citrus* sp. The female body is almost spherical and about 66 μ in diameter, with an offset neck and head. The lip region has a circum-oral elevation and the egg is almost spherical. The nematode is placed in *Sphaeronema* with certain reservations.

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8.30. GOODEY, J. B. & HOOPER, D. J. (1958). Observations on the effects of *Ditylenchus dipsaci* and *Anguina tritici* on certain wheat and barley varieties. *Nematologica*, **3**, 24–29.

Following the report in 1954 by Belloni that in Italy, *Triticum aestivum* L. was attacked by *Ditylenchus dipsaci*, varieties of wheat, barley and rye were tested for their reactions to *D. dipsaci*, derived from oats in Britain, and *Anguina tritici*. No variety of any cereal was attacked by *D. dipsaci*, but all the wheats, including several Italian varieties, were susceptible to *A. tritici*. It appears that the race of *D. dipsaci* attacking wheat in Italy is biologically different from the oat race of Britain. In Britain there is at present no real danger of attack by *D. dipsaci* on wheat or barley. Resistance of wheat to *D. dipsaci* does not infer resistance to *A. tritici*.

8.31. HESLING, J. J. (1958). The efficiency of certain grasses as hosts of the cereal-root eelworm *Heterodera major*. *Plant Path.* **7**, 141–143.

Cocksfoot, *Dactylis glomerata*, timothy, *Phleum pratense*, perennial ryegrass (*Lolium perenne*) and Italian ryegrass (*L. italicum*) were grown in pots of soils with different infestation levels of the cereal-root eelworm *Heterodera major*. Timothy is a very poor host. Although the other grasses increased the eelworm population, the increase was small compared with that caused by oats grown under similar conditions, and no significant differences in the host efficiency of these grasses could be shown.

8.32. HESLING, J. J. (1958). *Heterodera major*—population changes in the field and in pots of fallow soil. *Nematologica*, **3**, 274–282.

In fields on chalky soil in Hampshire and in fields on sandy soil in the West Midlands the cereal-root eelworm (*Heterodera major*) population increased when barley was grown, but decreased when grasses and non-host crops were grown. Frequent examination of infested fallow soil over a 2-year period showed that the eelworm population fell to about 40 per cent of its original value between March and mid-July; during the rest of the year there was little change. Barley sown in this soil at the end of the 2-year period produced large numbers of cysts.

8.33. HOOPER, D. J. (1958). *Aphelenchoides dactylocercus* n.sp. and *A. sacchari* n.sp. (Nematoda: Aphelenchoidea). *Nematologica*, **3**, 229–235.

The two new species *Aphelenchoides dactylocercus* and *A. sacchari* are described. The former is characterized by its narrow, finger-like tail and short, post-vulval sac. The latter is characterized by its rather short oesophagus, short female tail and the shape and small size of the spicules in the male. Both species have three incissures on the lateral field. These two species are fungivorous and are easily cultured on mushroom mycelium (*Agaricus hortensis* Cooke).

8.34. JONES, F. G. W. (1958). Resistance-breaking populations of potato-root eelworm. *Plant Path.* **7**, 24–25.

Further tests on twenty-five populations of potato-root eelworm were made. The results confirmed previous findings, namely that many populations contain biotypes capable of breaking the resistance of hybrids containing the gene H derived from *Solanum tuberosum* ssp. *andigena*. *Solanum vernei* proved resistant to all populations tested.

8.35. *SHEPHERD, A. M. (1958). Experimental methods in testing for resistance to beet eelworm, *Heterodera schachtii* Schmidt. *Nematologica*, **3**, 127–135.

After a short review of previous work on testing for resistance to beet eelworm, experiments on the variability arising in techniques for such tests are described. In pot tests with sugar beet, the variation in the number of cysts on plants of the same line under standard conditions is very high for all

* Work begun in the School of Agriculture, University of Cambridge.

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methods of inoculating, making detection of small differences in resistance impossible. Also, seasonal conditions affect cyst production. A technique for routine screening for resistance, involving the addition of hatched larvae to seedlings in small pots, is described. Selection for tolerance to attack, and the possible occurrence of resistance-breaking biotypes are also discussed. Because of the great variation encountered in pot tests, the necessity for careful planning of experiments and care in interpretation of results where such techniques are used, is stressed.

8.36. WALLACE, H. R. (1958). Movement of eelworms. II. A comparative study of the movement in soil of *Heterodera schachtii* Schmidt and of *Ditylenchus dipsaci* (Kühn) Filipjev. *Ann. appl. Biol.* **46**, 86–94.

Studies of mobility in horizontal tubes containing different soil fractions at different suctions and in single layers of particles, showed that the optimum particle size for movement of *Heterodera schachtii* and *Ditylenchus dipsaci* was 150–250 and 250–500 μ, respectively. In both species mobility was greatest when: (*a*) there were few pores smaller in diameter than the eelworm width; (*b*) the pore diameter was narrow enough to restrict lateral movement; (*c*) the tortuosity of the channels between particles was such that the body form of the eelworm had waves of long wavelength and short amplitude. By plotting tracks among water droplets it was possible to show quantitatively the relationship between the form of the body waves and the speed of the eelworms. The optimum temperature for movement was 15° C., for *H. schachtii* and 15–20° C. for *D. dipsaci*. The comparative study suggested that there was a simple relationship between body length, particle size and speed.

8.37. WALLACE, H. R. (1958). Movement of eelworms. III. The relationship between eelworm length, activity and mobility. *Ann. appl. Biol.* **46**, 662–668.

Tracks were plotted of about 300 individual eelworms comprising six species among water droplets on a glass surface. Measurements of the tracks indicated that the product of length and activity of an eelworm divided by its speed was a constant. This supports the hypothesis that the speed of an eelworm among water droplets is a function of its length and activity. The principle can be applied only to movement in soil where the length of the eelworm is less than about three times the particle diameter. Under such conditions the eelworms move in thin films or water droplets over particles. Among smaller-sized particles the speed of the eelworms is influenced by particle size. With increasing eelworm length there is an increase in soil particle size for maximum mobility.

8.38. WALLACE, H. R. (1959). Movement of eelworms. IV. The influence of water percolation. *Ann. appl. Biol.* **47**. (In the press.)

The relationship between rate of flow of water through sands of different particle size and the downward velocity of eelworms of various lengths and activities is not linear. For rates of flow less than about 500 cm./hour the velocity of the eelworms relative to the velocity of water is greater than for flow rates greater than about 500 cm./hour. For rates of flow greater than 500 cm./hour an equation is derived which relates velocity of eelworms, rate of water flow, length of eelworms and pore diameter in the sand. The velocity of the eelworms increases as pore diameter increases; the velocity approaches zero when the eelworms' length exceeds four times the pore diameter; the relationship between velocity of eelworm and velocity of water is independent of the eelworm's own activity; the equation of eelworm movement is valid for both continuous and discontinuous saturated flow. With flow rates less than about 500 cm./hour, the velocity of the eelworms increases as the eelworms' activity increases, and eelworms appear to pass through smaller pores than at high flow rates. Dead or inactive eelworms do not progress very far in sand even at high flow rates, and observations suggest that slight flexing movements of the eelworm body are essential for passage.

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8.39. WALLACE, H. R. (1958). Observations on the emergence from cysts and the orientation of larvae of three species of the genus *Heterodera* in the presence of host plant roots. *Nematologica*, **3**, 236–243.

Much work has been published on the influence of root diffusates on the emergence *in vitro* of larvae from cysts of different species of the genus *Heterodera*. There are also numerous references in the literature to larval emergence in the soil in the presence of host and non-host plants. There is, however, little information about larval emergence in the presence of plants where there is control of the environmental conditions. The question whether larvae of the genus *Heterodera* are attracted to roots has also received little attention, the only work in this connection being on the related genus *Meliodogyne* (Wieser 1955, 1956). The work herein described is an attempt to show how pressure deficiency (or suction) and moisture content in sand influence the rate of larval emergence from cysts of *Heterodera major* O. Schmidt, *H. schachtii* Schmidt and *H. rostochiensis* Wollenweber. The influence of the host plant on this relationship is examined and the problem of attraction of larvae to roots has also been studied.

8.40. WIDDOWSON, E. (1958). The production of root diffusate by potatoes grown in water culture. *Nematologica*, **3**, 108–114.

Potato plants (variety Arran Banner), were grown in 1 litre of plant nutrient solution, in tap water, and in distilled water, in black jars of 125 ml. capacity. The growth compared favourably with that of potatoes grown in pots of sand, but for at least the first 4 weeks of growth diffusate production was lower. No advantage was found in allowing diffusate to build up in the jars for several days, since it was possible to increase output during the later stages of growth by giving fresh nutrient solution every 1 or 2 days either by root or as a foliar spray.

8.41. WIDDOWSON, E. (1958). Some observations on the collection and storage of potato-root diffusate. *Nematologica*, **3**, 173–178.

Leaching Arran Banner potatoes with varying volumes of water showed that about 50 ml. of an active root diffusate can be taken thrice weekly from a plant in a 6½-inch pot. No increase in the yield of hatching factor resulted after heavier leaching. A mixture of three parts of loam to one of sand was a suitable mixture for growing potatoes for diffusate collection in the greenhouse, plants grown in sand were less vigorous, even with the addition of a plant nutrient. Samples of the same stock of a root diffusate broke down at a variable rate when stored separately, so that it is advisable to pool together all samples of a suitable activity and to store in bulk. Weekly assays of such bulk stocks stored at a temperature of 3–5° C. showed that activity remained stable for several months.

8.42. WIDDOWSON, E., DONCASTER, C. C. & FENWICK, D. W. (1958). Observations on the development of *Heterodera rostochiensis* Woll. in sterile root cultures. *Nematologica*, **3**, 308–314.

Details are given of techniques for setting up aseptic infestations of potato-root eelworm larvae in root tissues. The roots were grown in 0·75 per cent nutrient agar in test-tubes and eelworm eggs surface sterilized with 20 vols. H_2O_2 were added. Four or five days after inoculation, groups of active larvae were seen around the root tips, and maximum invasion usually occurred within 21 days of inoculation.

The parasites appeared to develop normally inside the tissues to adult males and virgin females. No free males were found, and none of the adult females examined contained eggs.

8.43. WIDDOWSON, E. & WILTSHIRE, G. H. (1958). The potato-eelworm hatching factor. *Ann. appl. Biol.* **46**, 95–101.

Root diffusate leached from pots of Arran Banner potatoes was acidified and extracted with powered charcoal. The factor was removed from the charcoal by elution with acetone. Some purification was achieved by transferring

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the active material from acid solution to butanol and then to bicarbonate. Stability tests, paper electrophorosis, ion exchange and chromatographic studies were made on such a preparation.

8.44. WINSLOW, R. D. (1958). The taxonomic position of *Anguillulina obtusa* Goodey, 1932 and 1940. *Nematologica*, **3**, 136–139.

Nematodes obviously identical with *Anguillulina obtusa* Goodey, 1932 and 1940 have been recovered from Rothamsted turf. Goodey believed this nematode to be identical with *Tylenchus obtusus* Bastian 1865, but the latter nematode is insufficiently described and figured to justify this, hence the specific name "*obtusa*" is invalid. Goodey's nematode is very close to *Pratylenchus* but didelphic, and the writer proposes for it the new generic and specific names *Pratylenchoides crenicauda*.

Insecticides and Fungicides Department

GENERAL PAPERS

9.1. BROADBENT, L., BURT, P. E. & HEATHCOTE, G. D. (1957). Insecticidal control of potato virus spread. *Proc. 3rd Conf. Potato Virus diseases, Lisse-Wageningen*, 91–105.

For summary see above page 248, No. 7.28.

9.2. MCINTOSH, A. H. (1958). Dipping methods. (In: *Methods of testing chemicals on insects*. Ed. H. H. Shepard. **1**, 130–153.) Minneapolis: Burgess Publishing Co.

9.3. POTTER, C. & WAY, M. J. (1958). Precision spraying. (In: *Methods of testing chemicals on insects*. Ed. H. H. Shepard, **1**, 154–258.) Minneapolis: Burgess Publishing Co.

9.4. WAY, M. J. (1956). A case for field beans. *Agriculture, Lond.*, **64**, 57–59.

9.5. WAY, M. J. (1958). The influence of other ant species on biological control of *Oecophylla longinoda* (Latr.). *Proc. 10th Inter, Cong. Ent., Montreal*, **4**, 595–596.

RESEARCH PAPERS

9.6. BARDNER, R. (1958). Seed dressings for the control of wheat-bulb fly. *Plant Path.* **7**, 125–129.

Twenty-seven different insecticides were tested as seed dressings. Treated seeds were sown in boxes of soil containing wheat-bulb fly eggs. Each insecticide was tested at two of three possible levels of application, viz. 0·04, 0·15 and 1 per cent of seed weight. No material was better than heptachlor at 1 per cent, but the following materials were comparable: γ-BHC (0·15 per cent), parathion (0·15 per cent), chlordane (1 per cent), endrin (1 per cent), isodrin (0·15 per cent and 1 per cent), dieldrin (0·15 per cent and 1 per cent) and DDT (0·04 per cent). Parathion and γ-BHC were phytoxic at these concentrations. No material gave complete protection, but the most successful treatments reduced the number of damaged stems by 50–70 per cent compared with untreated controls.

9.7. BARDNER, R. & KENTEN, JOYCE (1957). Notes on the laboratory rearing and biology of the wheat-bulb fly, *Leptohylemyia coarctata* (Fall.). *Bull. ent. Res.* **48**, 821–831.

The laboratory rearing of all stages in the life-history of the wheat-bulb fly, *Leptohylemyia coarctata* (Fall.), is described. The object of this work was to provide suitable material, in particular eggs and larvae, for insecticide experiments. Details of a container suitable for ovipositing adults are given.

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Several diets for the adults were compared, and it was found that the greatest number of eggs was produced when the flies were fed on beef blood and a mixture of sweetened condensed milk and honey. Females were found to lay up to 244 eggs each; egg-laying commences 9–15 days after emergence and continues almost as long as the females live, but reaches a peak 3–5 weeks after emergence. Some females survived from late June until early November. In a small laboratory population the average number of eggs laid by each female was 29·9 and mean length of life was 26·3 days for males and 41·6 days for females.

The eggs have a long obligatory diapause period. They have no effective water-proofing mechanism, but can recover from considerable temporary desiccation. A method of storage during diapause is described. The eggs normally hatch in late January or early February, but hatching can be delayed until much later in the year by storage below 0° C.

The effects of temperature on larval and pupal development are described. Larvae will grow at 20° C., but pupating larvae or young pupae are rendered sterile unless kept at temperatures of 15° C. or below. It is shown how a combination of delayed hatching and rapid larval and pupal development can produce fertile flies at unusual times of the year in the laboratory. It is suggested that this may make it possible to produce young larvae in the autumn for insecticide experiments.

In conclusion, some parasites and predators encountered in the field and the laboratory are mentioned.

9.8. ELLIOTT, M. (1958). Isolation and purification of (+)-pyrethrolone from pyrethrum extract: reconstitution of pyrethrins I and II. *Chem. & Ind.* 685–686.

Pyrethrolone and cinerolone, the alcoholic components of the insecticidal esters in pyrethrum extract, were regenerated from their semicarbazones by shaking with dilute sulphuric acid. (+)-Pyrethrolone mono-hydrate is crystalline; it was purified by recrystallisation from ether. This pyrethrolone, purer than earlier specimens, was used to produce and characterize pyrethins I and II by esterification with naturally derived chrysanthemic and pyrethric acids.

9.9. HEATHCOTE, G. D. & WARD, J. (1958). The preference shown by *Myzus persicae* (Sulz.) for *Brassica* plants sprayed with wetting agents. *Bull. ent. Res.* **49**, 235–237.

Insecticide formulations for spraying crops usually contain agents to disperse the insecticide and improve the wetting of the foliage. During a series of experiments to study the response of aphids to leaves sprayed with insecticide, it was noticed that more aphids often occurred on leaves which had been sprayed with a solution of wetting agent than occurred on unsprayed leaves. This paper gives evidence from these experiments for wetting agents seeming to attract aphids, and describes other experiments done specifically to investigate the question.

9.10. LAST, F. T. (1958). Stem infection of cotton by *Xanthomonas malvacearum* (E.F.Sm.) Dowson. *Ann. appl. Biol.* **46**, 321–335.

Varying the position of stem inoculation, the concentration of inoculum and the age of plant affected the reaction of cotton, *Gossypium* sp., to infection with *Xanthomonas malvacearum* (E.F.Sm.) Dowson.

The extent of stem discoloration, internal and external, and the probability of disease occurring in leaves by bacteria moving within the plant increased (*a*) the nearer the point of stem inoculation was to the apex, and (*b*) the higher the concentration of inoculum. The leaf symptoms were not the angular spots typical of primary leaf infection. Instead, bacteria seemed to lodge in, discolour and blacken sections of leaf veins. Then tissue next to the affected veins became water-soaked and leaf sectors dependent upon these veins died and dried. These symptoms usually developed 14 to 55 days after inoculation in the expanding leaves.

The amounts of stem discoloration and the probabilities of leaf symptoms developing were less when hypocotyls of old plants were inoculated than when hypocotyls of young plants were inoculated. The probabilities of leaf symp-

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toms developing were similar, however, when young tissues in young and old plants were inoculated.

American cotton, *Gossypium hirsutum*, was less affected by stem inoculation than Egyptian cotton, *G. barbadense*. Of the resistance factors against primary leaf infection only B_{6m} gave appreciable stem resistance.

9.11. LAST, F. T. & (DRANSFIELD, M.) (1959). Measurement of the resistance of cotton to *Xanthomonas malvacearom* (E.F.Sm. Dowson) using a leaf abrasion technique. *Emp. Cott. Gr. Rev.*

The numbers of lesions (angular leaf spots) per unit area and their rates of development were assessed on a range of cottons after abrading leaves with carborundum and then rubbing with a suspension of *Xanthomonas malvacearum*. Fewer lesions developed (1) on American cottons, *Gossypium hirsutum*, than on Egyptian cottons, *G. barbadense*, and (2) on varieties with resistance factors than on fully susceptible plants. The combination of factors $B_2B_3B_6$ gave the least number of lesions—1·8 lesions/sq. cm. against 13·9 on the fully susceptible plants. The average rate of lesion development was significantly decreased by the combinations B_2B_3 and $B_2B_3B_6$.

9.12. WAY, M. J. (1958). Effects of demeton-methyl on some aphid predators. *Plant Path.* **7**, 9–13.

The systemic insecticide demeton-methyl has proved outstanding as a powerful aphicide which is safer to mammals than demeton or schradan. In Britain it was used extensively in 1957 to stop aphid attacks on many crops and also in attempts to prevent spread of aphid-transmitted virus diseases. Little is known about its possible harm to beneficial insects; field experiments were therefore done to compare its action on some aphid predators with that of parathion, which is known to kill many predators, and schradan, which is virtually harmless to them.

9.13. WAY, M. J. & BANKS, C. J. (1958). The control of *Aphis fabae* Scop. with special reference to biological control of insects which attack annual crops. *Proc. 10th int. Congr. Ent., Montreal* (1956), **4**, 907–909.

Aphidae by their powers of rapid reproduction and efficient dispersal seem well adapted to annual hosts. Chemicals are widely used to control them, but relatively little is known about their control by natural enemies or about the effect of chemicals on this. This paper describes techniques being used in an attempt to evaluate the effects of natural enemies on populations of *Aphis fabae* Scop. Where relevant, chemical and biological controls are compared. First results indicate that, when the aphid is on an annual crop in midsummer, its predators and parasites are a minor factor in its control, and chemical control is necessary if an attack develops. From August to the following May *A. fabae* is on weeds and shrubs often in natural or semi-natural environments. Here, predators and parasites may be a major controlling factor, and hence may determine the number of migrant aphids which in May and June depart to the midsummer host. This is important because the size of the aphid population which develops on the midsummer host and the crop loss are directly related to the number of migrants reaching it.

Insecticides applied to the midsummer host plant deplete the predator population available to attack the aphid on its later hosts. This could have harmful effects.

9.14. WAY, M. J., BARDNER, R., BAER, R. VAN & (AITKENHEAD, P.) (1958). A comparison of high- and low-volume sprays for control of the bean aphid, *Aphis fabae* Scop. on field beans. *Ann. appl. Biol.* **46**, 399–410.

Insecticides were sprayed in different amounts of water to control *Aphis fabae* Scop. attacking spring-sown field beans. The single application of each insecticide was timed to coincide with the end of aphid migration from the winter host to the crop. A tractor-mounted row-crop hydraulic sprayer was used.

In one experiment seven different insecticide sprays were compared at high volume (in 140 gallons of water/acre); the most effective were nicotine at 22·4

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oz. of active constituent/acre, demeton at 5·6 oz. and demeton-methyl at 11·2 oz.

A further comparison was made of five insecticides for each of which a selected dose of active ingredient was applied in 60 gallons (medium volume) and in 10 gallons of water/acre (low volume). The amount of insecticide retained on the plant following the low-volume application was not less than that from the medium-volume spray; the efficiency of *A. fabae* control was not affected by the volume sprayed except with malathion, which did better at the medium volume. The systemic insecticide demeton-methyl at 6 oz. of active constituents/acre, the related compound 4741 at 3 oz./acre and fluoroacetamide at 3 oz./acre stopped the aphid numbers from rising above a peak of eight per plant compared with 230/plant for malathion (low volume) at 12 oz.; 2400/plant for lindane at 6 oz., and 3,550/plant for check treatments sprayed with wetter only. Grain yields ranged from around 4 cwt./acre on check treatments to around 27 cwt./acre on plots sprayed once with the systemic insecticides. There was a curvilinear relationship between grain yield and log number of *A. fabae* per plant.

Entomology Department

Book

10.1. Mellanby, K. (1958). *The birth of Nigeria's university.* London: Methuen.

Research Papers

10.2. Banks, C. J. (1957). The behaviour of individual coccinellid larvae on plants. *Brit. J. Anim. Behav.* **5**, 12–24.

The larvae moved on bean leaves, as they did on a flat piece of paper, with frequent changes in direction, but the edges and prominent veins of leaves often determined the pattern of their tracks. The chance touching of leaves of adjacent plants influenced their direction of movement and, when aphid colonies on bean plants were few, larvae might by chance be led far away from them. Coccinellid larvae wasted time and energy in repeatedly visiting parts of plants which they had already visited.

Larvae which encountered aphid colonies tended to stay near them, because after feeding they made small turning movements from side to side, which increased the chance of meeting another aphid of a colony. This behaviour was different from the behaviour before feeding. Fleschner's (1950) conclusion that larvae are unable to perceive the prey from a distance was confirmed.

Larvae (especially the first and second instar) took a comparatively long time to consume aphids and, in the field, one of them was prevented from feeding on an aphid colony by the attacks of ants which were attending them.

The behaviour of larvae is discussed in relation to their survival in the field. It is considered likely that in areas of low prey density many larvae (especially newly hatched ones) die of starvation because they do not find aphids.

10.3. Banks, C. J. (1958). Effects of the ant, *Lasius niger* (L.), on the behaviour and reproduction of the Black Bean Aphid, *Aphis fabae* Scop. *Bull. ent. Res.* **35**, 703–711.

Cage experiments confirmed that, in the absence of natural enemies, populations of *Aphis fabae* Scop., attended on bean plants (*Vicia faba*) by the ant, *Lasius niger* (L.), multiply more rapidly than otherwise similar but ant-free populations. The average difference in numbers recorded was about one-third, the maximum being 70 per cent. No doubling or trebling of aphid numbers as claimed by an earlier worker was ever recorded.

When the aphids are attended by ants, their excretion behaviour alters and the normal dispersal of the apterae from the young apical growth of bean plants is considerably delayed.

No significant differences were found between the numbers of nymphs

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produced by individual aphids from ant-visited and ant-free plants, respectively, living on leaves of the same age; but the numbers were significantly affected by the age of the leaf or part of the plant on which the aphids had developed or were then feeding.

It is suggested that ant-attended aphid populations multiply more rapidly because most of the aphids feed for a much longer time on young plant tissue, where, presumably, their food supply is more nutritious.

10.4. BANKS, C. J. & NIXON, H. L. (1958). Effects of the ant, *Lasius niger* L., on the feeding and excretion of the Bean Aphid, *Aphis fabae* Scop. *J. exp. Biol.* **35**, 703–711.

Ant-attended aphids excreted twice as much ^{32}P as ant-free aphids did, by increasing their uptake of sap from radioactive broad bean plants. The aphid directly controls its feeding and excretion rates, which are not determined solely by forces within the plant. In the normally feeding aphid, sap uptake, which is apparently not continuous, seems to be regulated by the "sucking pump" in the head.

10.5. BARNES, H. F. (1958). Biosystematics as applied to the Cecidomyidae. *Proc. 10th int. Congr. Ent.* (1956) **1**, 165–170.

An informative account of the methods used at Rothamsted Experimental Station together with the results of testing the identity of a new *Contarinia* pest of Shasta Daisy. It was shown to be *C. chrysanthemi* Kieffer of wild ox-eye daisy.

10.6. BARNES, H. F. (1958). Experimental inter-breeding of Hessian Fly from Kansas, U.S.A., Germany and England. *Z. PflKrankh.* **65**, 333–43.

Hessian fly from the above countries will inter-breed freely, so it is concluded that there is now no reason to doubt that *Mayetiola destructor* (Say) occurs in Europe. Information is given on the occurrence of unisexual families, fecundity, time of day of emergence, and oviposition and the speed of development.

10.7. BARNES, H. F. (1958). The gall midges (Dipt., Cecidomyidae) of Timothy grass inflorescences, with the description of one new species. *Ann. ent. fenn.* **24**, 59–68.

Contarinia kanervoi is described and notes given on its biology. *Stenodiplosis geniculati* of meadow foxtail grass is shown to use Timothy grass as a host plant for its summer generation. The speed of development on its various host plants is discussed. A third injurious species, *Dasyneura* sp., is mentioned, as are an inquiline *Clinodiplosis* sp. and a predacious *Lestodiplosis* sp.

10.8. BARNES, H. F. (1958). A new stem-inhabiting gall midge of *Poa pratensis* (Diptera: Cecidomyidae). *Beitr. Ent.* **8**, 688–692.

A new species from Germany belonging to the genus *Mayetiola* is described as *M. schoberi*.

10.9. BARNES, H. F. (1958). Progress in the biological testing of sorghum midge (*Contarinia* spp.). *Bull. ent. Res.* **49**, 555–558.

Successful emergence of a *Contarinia* species and its parasites have been obtained at Rothamsted Experimental Station from midge-infested heads of sorghum received from India and West Africa. Inter-mating between midges from Ghana and Mysore took place.

10.10. BARNES, H. F. (1958). Wheat Blossom Midges on Broadbalk, Rothamsted Experimental Station, 1927–56. *Proc. 10th int. Congr. Ent.* (1956) **3**, 367–374.

A summary of this 30-year investigation with emphasis laid on the necessity for presampling in order to ascertain the correct date on which to take the main sample for the year, the relationship between the numbers of

larvae and the number of grains shrunken by *S. mosellana* and lost due to *C. tritici*, the periodicity of the two midges and their parasites, and the two periods of cessation of activity exhibited by the larvae.

10.11. CHERRY, L. M. (1959). Fat metabolism and temperature acclimatization in the fly, *Phormia terraenovae* R.-D. *Ent. exp. & appl.* **2**, 60–76.

Larvae of the fly *Phormia terraenovae* R.-D. were reared in an insectary at approximately 18° C., and fed on the following foods: yeast/milk, pork, mutton, beef, herring.

When the larvae were fully grown, they were killed and analysed. Larvae from all diets were similar in constitution, except for the Iodine number of the body fat. This varied as follows: milk yeast diet = 62, pork = 70, mutton = 71, beef = 69, herring = 90. The differences between pork, mutton and beef fed larvae were not significant, but the other differences were highly significant.

The differences between the iodine values of the fats in the various foods were greater than those found in the larvae which fed on them (milk yeast = approximately 30, pork = 60, herring = 130).

Larvae reared on mutton at 35° C. contained fat with an Iodine number of 64 (as against 71 for those reared at 18° C.).

The thermal death points for all the larvae reared at 18° C., whatever their diets, were approximately the same. The larvae reared at 35° C. had a thermal death point approximately 1° C. higher.

There appears to be little or no relationship between the composition of the body fat of *Phormia* larvae and their resistance to high temperature.

10.12. DOBSON, R. M., STEPHENSON, J. W. & LOFTY, J. R. (1958). A quantitative study of a population of Wheat-bulb fly, *Leptohylemyia coarctata* (Fall.), in the field. *Bull. ent. Res.* **49**, 95–111.

A new method of studying the bionomics of wheat-bulb fly in the field is described. The method combined the use of large field cage with a method of marking and recapture, and daily emergence figures, the rate of population decay and the structure of the population in terms of sex ratios and absolute numbers were investigated. Observations on the populations of the immature stages were also made.

10.13. FRENCH, R. A. (1958). Migration Records 1957. *Entomologist*, **91**, 101–109.

10.14. JOHNSON, B. (1958). Factors affecting the locomotor and settling responses of alate aphids. *Anim. Behav.* **4**, 9–26.

In suitable environmental conditions for flight, alate aphids typically fly from their parent host plants, and they cannot normally be brought to settle down on those or other plants until after they have engaged in flight or other activity. In unsuitable flight conditions they remain on the plants but do not respond to them by feeding and reproducing. Aphids alighting on plants after flight normally spend some time wandering and probing, and they may settle down.

By allowing young alatae of *Aphis fabae* Scop. short tethered and untethered flights of a minimum of 10–20 seconds and then putting them on a leaf surface, it was possible to induce wanderings and probing behaviour. There is evidence that aphids do not normally alight and show this behaviour after being airborne for such a short time, and the behaviour of the aphids in the experiments was probably due to the composite effect of flight and some part of the experimental procedure. Wandering and probing behaviour could also be produced by giving aphids a knockdown dose of CO_2, and by allowing them an extensive period of activity other than flight.

The length of time aphids spent wandering on plants before they took off again, and whether or not they settled down to feed and reproduce, was influenced by the length of flight they had engaged in, the nature of the surface they were released on and the physical environment.

The effect of both short and long flights was soon lost, and in the absence

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of strong contralocomotory stimuli, such as darkness or a very suitable host, the aphids reverted to typical locomotory behaviour after showing some degree of the settling response (i.e., wandering and probing or settling down for some time).

Much of the behaviour of alate aphids can be grouped under two opposing general responses—the locomotor response and the settling response; it is suggested that the stimuli determining the type and strength of response of aphids at any time are principally of the same kinds as those which were shown in the experiments to affect the strength of the settling response.

10.15. Long, D. B. (1958). Field observations on adults of the wheat-bulb fly. (*Leptohylemyia coarctata* (Fall.).) *Bull. ent. Res.* **49**, 77–94.

A study of adult populations of wheat-bulb fly, *Leptohylemyia coarctata* (Fall.), has been carried out in the field by routine sweeping at Rothamsted. It has been observed that the males emerge slightly before the females and that the emergence period may cover at least three weeks in late June and early July. Although the number of males may exceed the number of females at first, the females predominate later in the season due to the shorter life span of the males.

The numbers of flies on the wheat have been found to fluctuate appreciably throughout the day. During the first week of the emergence period the number of flies taken increased steadily throughout the day. After the date of population peak, however, the maximum numbers occurred in the crop in the very early morning and the late evening, which suggested a daily flight dispersion followed by a general or localized return of the flies to the crop. Further study of the data showed that the daily temperature rhythm was only partly responsible for this daily flight dispersion, and that there appeared to be an active return flight to the crop in the evening. Generally the males were more active than the females and did not settle so deeply in the crop.

The temperature threshold for flight was observed to be 12°–13° C. Winds up to 8 m.p.h. did not appear to affect flight activity, but higher winds, e.g., 15 m.p.h., markedly reduced flight, the flies remaining deep in the crop near ground level. Gale-force winds, however, were observed to produce a permanent depletion in the number of flies infesting Broadbalk field, indicating that the population was probably localized.

Although portions of the populations dispersed fairly rapidly from the emergence sites, recaptures of radioactive flies labelled with P^{32} indicated that the extent of the dispersions was not very great. The females dispersed more than the males, and were influenced to some extent by the occurrence of wheat in flower. Frequently the flies were found to have congregated on the lee edge of the crop, but other preferred regions have been observed which could not be attributed to the influence of the wind.

10.16. Long, D. B. (1958). Host plant location by larvae of the wheat-bulb fly (*Leptohylemyia coarctata* Fallen). *Proc. R. ent. Soc. Lond.* (A) **33**, 1–8.

The mechanism of host plant location by newly hatched larvae of the wheat-bulb fly has been studied by inoculating pots of prepared young wheat plants and by direct observations of movement in petri dishes.

The results of pot experiments suggest that the larvae move upwards at a fairly steep angle from the egg site and then horizontally in the surface layers of soil. Plant location did not appear to occur as the result of random movements but involved a larval response to attractant material exuding from the plant. The root extremities were not involved in this process, but when roots close to the base of the plant were exposed to the larvae, appreciable infestation of the plants occurred. The highest level of infestation occurred in plants in which the stems only were exposed, indicating that the stems played the major role in the location mechanism and that the attractive root zone may actually interfere with infestation.

The attractiveness of the exudates from the root and stem regions was supported by direct observation of larval movements in petri dishes. Leaf-tip exudates in the form of guttation droplets were also found to be attractive and may, on reaching the soil, reinforce the stem exudates. The attractiveness of the exudates was reduced by boiling.

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10.17. LONG, D. B. (1958). Observations on the occurrence of larval infestations of wheat-bulb fly, *Leptohylemyia coarctata* (Fall.). *Bull. ent. Res.* **49**, 113–122.

The effect of the previous crop on the subsequent infestation of winter wheat by the wheat-bulb fly, *Leptohylemyia coarctata* (Fall.), mainly on the clay-loam of Rothamsted Experimental Farm has been investigated for the years 1954–56. By far the highest larval populations followed fallows, the next highest potatoes, which are a low, open cover crop, whilst much lower populations followed the tall crops of beans and wheat, and very small infestations followed the grass mat covers. This confirms the results of previous workers under different agricultural conditions.

Previous applications of dung and straw influenced the infestation following fallow in dry summers but not in a wet year. The effects of other manurial treatments were inconclusive.

An experiment designed to determine the effect of the crop density on oviposition was inconclusive, due to the failure to establish an infestation.

Wheat was shown to influence the flight path and to interfere with local egg-laying behaviour, producing a horizontal effect of up to twice its own height.

Apart from the foregoing factors at Rothamsted, where the wheat fields are well separated, the differences in the level of infestation that were observed could be explained by close proximity or otherwise to a centre of heavy fly infestation.

Reasons are put forward for suggesting that the effect of the previous crop on oviposition may be interpreted in terms of the opportunity existing for contact with the soil rather than as a preference on the part of the fly.

10.18. LONG, D. B. (1958). Observations on oviposition in the wheat-bulb fly, *Leptohylemyia coarctata* (Fall.). *Bull. ent. Res.* **49**, 355–366.

In laboratory cultures of wheat-bulb fly, *Leptohylemyia coarctata* (Fall.), a daily oviposition rhythm was observed in which egg-laying was virtually restricted to the afternoon and evening with maximum laying occurring in the two hours before nightfall. The time of oviposition coincided with that part of the diurnal flight rhythm, earlier observed, in which the flies actively congregated on wheat, and this, it is suggested, could account for the fact, already recorded, that laying has been found to occur mostly on sites close to an infested crop.

The oviposition rhythm was maintained for 24 hours in absence of light, and therefore appeared to be partly inherent. However, it could be influenced by the times of exposure to light and disappeared in constant light. Darkness did not appear to affect the egg-laying rate, but a temporary increase followed exposure to continuous light. Within the course of the experiments the rate was not affected by small changes in temperature.

The individual fly laid up to 180 eggs in the laboratory in periodic batches of up to 42 eggs laid over periods of 1–6 days. This periodicity was obscured in cages containing a number of flies. Disproportionately small decreases in the mean daily laying rate occurred with increases in this laying period. Within the laying period the rate progressively increased with each successive day. The total number of eggs laid was not related to the number of ovarioles. In the laboratory the rate of laying increased with age and most of the eggs were laid by relatively few flies.

The rate of egg-laying and survival at different stages in the field is discussed and it is suggested that about 2 per cent of the eggs successfully develop as matured females which lay an average of about 50 eggs each.

10.19. LONG, D. B. & ZAHER, M. A. (1958). Effect of larval population density on the adult morphology of two species of Lepidoptera, *Plusia gamma* L. and *Pieris brassicae* L. *Ent. exp. & appl.* **1**, 161–173.

The morphological effects of population density in locusts in the production of " phases " is now well established, and in recent years somewhat parallel effects have been observed in the larvae of Lepidoptera. Unlike locusts, Lepidoptera pass through a quiescent pupal period, but nevertheless the adult

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may be affected. In both *P. gamma* and *P. brassicae* adults from crowded larval cultures were smaller in both size and weight, although the effect was counteracted to some extent by approaching pupal diapause in *P. brassicae*. The effect was similar in many cases to that produced by an increase in temperature, except that it disturbed the relationships between the lengths of the wing and hind femur with the live weight. The ratio of these lengths (equivalent to E/F ratio in locusts) was significantly increased, but was not a satisfactory index of larval population density. No effects were observed in the wing pattern and coloration in either species.

10.20. MELLANBY, K. (1958). The alarm reaction of mosquito larvae. *Ent. exp. & appl.* **1**, 153–160.

The alarm reaction in three species of mosquito larvae has been investigated.

All larvae disappear from the surface of the water when " alarmed ", but the mechanism of the reaction differs in the different species. *Aedes aegypti* is lighter than water. It swims actively to the bottom, and returns passively to the water surface by floating upwards. *Culex* and *Anopheles* larvae are heavier than water. They sink passively to the bottom when alarmed; return to the water surface is an active process, necessitating swimming by the larvae.

Repeated stimulation produces " stimulus-satiation ". When a larva ceases to react to one stimulus (e.g., vibration) it will react immediately to another (e.g., light), which suggests that the sensory receptors become adapted but that the effector muscles are not fatigued.

After stimulation *Aedes* larvae are negatively phototactic. They are also positively geotactic, but the phototaxis is the stronger reaction. *Culex* and *Anopheles* relax when " alarmed " and, in this condition, they sink passively in the water; they do not react to changes in light intensity.

The chill coma temperature is several degrees cooler than the lowest temperature at which the alarm reaction takes place. Acclimatization, which takes under 24 hours, can alter the position of both the chill coma temperature and that at which the alarm reaction takes place.

10.21. MELLANBY, K. (1958). Water content and insect metabolism. *Nature, Lond.* **181**, 1403.

10.22. MELLANBY, K. (1958). Water drinking by the larva of the European Corn Borer. *J. econ. Ent.* **51**, 744–745.

Larvae, after their winter diapause, drink water and resume activity. They do not absorb water through the cuticle, as was previously believed.

10.23. MELLANBY, K. & FRENCH, R. A. (1958). The importance of drinking water to larval insects. *Ent. exp. & appl.* **1**, 116–124.

Many insect larvae have been found to drink water. These include larvae inhabiting stored products, phytophagous species, larvae found in the soil and species dehydrated during diapause. The water taken in may enable the larvae to withstand unfavourable conditions.

10.24. MURPHY, P. W. (1958). The quantitative study of soil meiofauna. I. The effect of sample treatment on extraction efficiency with a modified funnel extractor. *Ent. exp. & appl.* **1**, 94–108.

Construction details of the split-funnel extractor, a modified funnel method for extracting soil fauna are given, together with results of an experiment to test the apparatus, and the effect of sample treatment on extraction of Acarina from heathland samples.

10.25. MURPHY, P. W. (1958). The quantitative study of soil meiofauna. II. Sample preparation and routine methods for handling the catch. *Ent. exp. & appl.* **1**, 109–115.

Details of a method for preparation of undisturbed samples for extraction with a modified funnel are given, together with techniques for the quantitative assessment of the catch (especially Acarina and Collembola). These techniques include handling, visual examination and storage of the fauna.

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10.26. MURPHY, P. W. (1958). Soil faunal investigations. *Rep. For. Res.* for 1957.

10.27. RAW, F. (1959). An insectary method for rearing the cacao Mirids *Distantiella theobroma* (Dist.) and *Sahlbergilla singularis* (Hagl.). *Bull. ent. Res.* **50**. (In the press.)

Adults are caged for oviposition on cacao seedlings grown in baskets. When the eggs hatch the nymphs are transferred to, and reared on, unripe cacao pods suspended in ventilated glass cages.

10.28. RAW, F. (1959). Studies on the chemical control of the cacao Mirids *Distantiella theobroma* (Dist.) and *Schlbergilla singularis* (Hagl.). *Bull. ent. Res.* **50**. (In the press.)

Laboratory and field tests were made to investigate the toxicity, mode of action and persistence of DDT and BHC when applied to cacao to control the mirids *Distantiella theobroma* Dist. and *Sahlbergilla singularis* Hagl. Preliminary tests with aldrin, chlordane and dieldrin were also made.

BHC had a higher toxicity and acted much quicker than DDT. It also greatly reduced feeding. BHC had a powerful but transient fumigant action. DDT had no fumigant action. In field tests DDT persisted longer than BHC, but was probably ineffective after 3–4 weeks. Some results suggested that BHC had a local systemic action.

It was concluded that BHC would be more effective than DDT when treating mature cacao because, in addition to its higher toxicity and quicker action, its fumigant action would compensate for incomplete coverage by low-volume spraying.

Of the other insecticides tested, aldrin had a high toxicity and fumigant action and appeared to be the most promising alternative to BHC.

10.29. STEPHENSON, J. W. (1958). *The biology of* Brachydesmus superus *Latz.* (M.Sc. thesis, University of London.)

10.30. STOKES, B. M. (1958). Hessian fly on Rothamsted Farm. *Plant Path.* **7**, 22–24.

Wheat on Broadbalk field and on Hoosfield at Rothamsted Farm was sampled in 1954, 1955 and 1956. Infestation of straws ranged from 5·8 to 1·3 per cent, and of tillers from 42·3 to 0·0 per cent. No statistically significant differences between years or plots were found.

10.31. STOKES, B. M. (1958). The worm-eating slugs *Testacella scutulum* Sowerby and *T. haliotidea* Draparnaud in captivity. *Proc. malac. Soc. Lond.* **33**, 11–20.

Specimens of *Testacella scutulum* Sowerby and *T. haliotidea* Draparnaud were kept in jars in captivity and observed daily for over a year. They were weighed each week, and records were kept of the numbers of worms they ate. Mating, oviposition and the hatching of eggs were seen. Data were obtained on the feeding and growth rates of the young slugs.

10.32. WAY, M. J. & BANKS, C. J. (1958). The control of *Aphis fabae* Scop. with special reference to biological control of insects which attack annual crops. *Proc. 10th int. Congr. Ent.* (1956), **4**, 907–909.

For summary see above, p. 261, no. 9.13.

Bee Department

BOOK

11.1. FREE, J. B. & BUTLER, C. G. (1959). *Bumblebees.* (New Naturalist Series.) London: Collins.

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General Papers

11.2. Bailey, L. (1958). Wild honeybees and disease. *Bee World*, **39**, 92–95.

11.3. Butler, C. G. (1958). Queen supersedure and swarming. *Rep. cent. Ass. Brit. Beekeep. Ass.*

11.4. Butler, C. G. (1959). Sex determination and caste differentiation in the honeybee (*Apis mellifera*). *Mem. Soc. Endocrinol.* 7. (In the press.)

11.5. Free, J. B. (1958). The behaviour of honeybees when their hive is moved to a new site. *Bee World*, **39**, 109–115.

11.6. Free, J. B. (1958). The production of egg-laying workers in bumblebee colonies. *Insect. Soc.* (In the press.)

11.7. Free, J. B. (1958). The transfer of food between the adult members of a honeybee community. *Insect. Soc.* (In the press.)

11.8. Simpson, J. (1958). The problem of swarming in beekeeping practice. *Bee World*, **39**, 193–202.

Research Papers

11.9. Bailey, L. (1958). The epidemiology of the infestation of the honeybee, *Apis mellifera* L., by the mite *Acarapis woodi* Rennie, and the mortality of infested bees. *Parasitology*, **48**, 493–506.

Transmission of infection to young honeybees was facilitated, in laboratory experiments, by increased temperature and increased infection of old infected bees, and, in field experiments, by inactivity of foraging bees. Mortality of infected bees was only slightly greater than of those uninfected. Colonies with more than 30 per cent of bees infected were more likely to die than uninfected colonies, and those with more than 75 per cent of bees infected were certain to die; but few colonies became so heavily infected. Death always occurred in late winter.

11.10. Butler, C. G. & Simpson, J. (1958). The source of the queen substance of the honeybee (*Apis mellifera* L.). *Proc. R. ent. Soc.* (*A*), **33**, 120–122.

It is shown that the contents of the mandibular glands of a mated queen honeybee, but not of a worker bee, are capable of inhibiting queen production by queenless worker honeybees. No such effect was produced by the haemolymph of a queen or by crushed brain or ovaries. It is concluded that the mandibular glands of the queen honeybee produce queen substance.

11.11. Free, J. B. (1958). The ability of worker honeybees (*Apis mellifera*) to learn a change in the location of their hives. *Anim. Behav.* **6**, 219–223.

When the site of a colony of honeybees was changed, and other colonies were put near the old site, nearly all the bees which returned there from the new one attempted to join them. When there were no colonies near to the old site, 69–100 per cent of the bees returned to their colony in its new position, although many of them visited the old site first. Some bees also visited the old site on subsequent occasions; the behaviour of the individual bees varied greatly.

The proportion of bees visiting the old site depended on the distance between old and new sites, and decreased with increase in the distance their colony had been moved. The greater the distance between old and new sites, the longer bees spent at the old site before returning to the new one, and the less likely they were to return to the new one.

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11.12. FREE, J. B. (1958). Attempts to condition bees to visit selected crops. *Bee World*, **39**, 221–230.

The literature dealing with attempts to condition bees to visit selected crops and the techniques employed are briefly reviewed.

In the experiments described attempts were made to direct bees to visit crops of apple and red clover. The results were ascertained by comparing the percentage of pollen from the crop concerned which was collected by the "directed" and control colonies. No beneficial effect of directing was apparent, and it is considered that more conclusive results are desirable before the practice of directing bees to crops can be recommended in Britain.

11.13. FREE, J. B. (1959). The drifting of honeybees (*Apis mellifera*). *J. Agric. Sci.* **51**, 294–306.

The majority of bees that drift do so during orientation flights before they become regular foragers. Bees emerging in August and September drift less than those emerging earlier in the year. The amount that bees drift varies considerably in different circumstances, and may be very great. Drones drift two or three times as much as workers.

Proportionately more bees drift from small to large colonies than *vice versa*, but the greater number of bees flying from the large colonies results in a net gain in bees by the smaller ones.

When hives are arranged in repetitive patterns, bees drift to hives occupying similar positions in other patterns to the ones their hives occupy in their own pattern. When hives are arranged in rows, bees from the central colonies drift more than those at the ends, resulting in the latter colonies gaining numerically. In some circumstances more bees drift to hives in one direction than in the opposite one. If hives are arranged to face in different directions, and are painted different colours, drifting is considerably reduced. The facing of the hives in different directions reduces drifting more than painting them different colours.

11.14. FREE, J. B. & BUTLER, C. G. (1958). The size of apertures through which worker honeybees will feed one another. *Bee World*, **39**, 40–42.

If bees are to feed one another through the apertures in wire-gauze these need to be considerably larger than the cross-section of a bee's tongue, since feeding will only take place if antennal contact is possible. It is concluded that apertures of not less than 2·5 mm. square are desirable in wire-gauze used in the construction of queen cages.

Statistics Department

GENERAL PAPERS

12.1 CHURCH, B. M. (1959). The uses of fertilizer practice surveys and appropriate survey techniques. *FATIS Rev.* (In the press.)

12.2. YATES, F. (1959). The introduction of electronic computers in research statistics. *Rep. agric. Res. Coun.* for 1957/58.

12.3. YATES, F. (1958). Second Report to the Government of India on statistics in agricultural research. *F.A.O. Rep.* 987.

RESEARCH PAPERS

12.4. BOYD, D. A. (1959). The effect of farmyard manure on fertilizer responses. *J. agric. Sci.* (In the press.)

Farmyard manure affected the response of the potato crop to fertilizers similarly in seven series of experiments (sixty-two in all) at Rothamsted, and in the West Midlands and north of England.

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In the absence of FYM there were large interactions between each of the fertilizer nutrients, but with FYM the interactions were small. These interactions appear to have been ignored by previous workers, who claimed that nitrogen responses are unaffected by dressings of FYM. In fact, FYM increased the response to nitrogen applied alone, but decreased the nitrogen response where basal P and K fertilizers were also applied. For phosphate the results were similar to those for nitrogen.

Most of the experimental sites were low in potash, and potash responses were very large, especially in the presence of basal NP fertilizer. Farmyard manure greatly reduced the response to potash, particularly in the presence of basal NP fertilizer.

Rothamsted experiments testing FYM and fertilizers and several times of planting showed that the large responses to FYM alone and to fertilizers used in combination (but without FYM) were not reduced by late planting. The result conflicts with previous reports of these data, in which interactions between nutrients were ignored. The combined effect of FYM and fertilizers at late planting was little more than their separate effects, presumably due to delayed maturity, the influence of which would be exaggerated by the early burning-off of haulm in this series of experiments.

Most of the experiments were limited to testing fertilizers at two levels (presence and absence), so the effective quantities of nutrients provided by FYM for the crop to which it was applied could only be estimated approximately; the average amounts suggested for normal FYM are 0·3 cwt. N, 0·4 cwt. P_2O_5 and 0·75 cwt. K_2O in 10 tons FYM.

These results lead to the practical conclusion that, in manuring potato crops on average land, much the same plant food ratios will be appropriate whether or not FYM is given, and the amount of fertilizer applied can be decreased to allow for the nutrients contained in the FYM.

12.5. CHURCH, B. M. (1958). Report to the Government of Ethiopia on the development of agricultural statistics. *F.A.O. Rep.* 889.

This report was prepared on the termination of a 15-month assignment to Ethiopia under the auspices of the Food and Agriculture Organization of the United Nations. The purpose of the assignment was to assist the Government in initiating a system of current agricultural surveys and censuses, particularly by setting up pilot surveys to test appropriate sampling methods and by the training of field and office personnel.

A programme for the development of an agricultural statistics service is outlined, and attention is drawn to specific survey and pilot investigations which should be undertaken as the organization is being built up. Surveys of the Addis Ababa milk supply, a general survey of livestock in semi-nomadic regions of southern Ethiopia and a pilot survey of land utilization and cropping undertaken during the assignment are briefly described.

12.6. (FIDLER, J. H.), CHURCH, B. M. & (SOUTHEY, J. F.). (1959). Field sampling and laboratory examination of cereal-root eelworm cysts. *Plant. Path.* (In the press.)

Co-operative sampling experiments undertaken by the Advisory Entomologists are described. The sampling errors of estimated cyst population densities, due to within-field heterogeneity and due to laboratory examination are estimated. Laboratory examination of 200 gm. soil taken from a well-mixed bulk sample of 2,500–5,000 gm. obtained from 50 or so randomly located points in a field normally provides an estimate of sufficient accuracy for advisory purposes. Recommendations are made for uniformity in details of laboratory technique.

12.7. GOWER, J. C. (1958). A note on an interative method for root extraction. *Comp. J.* **1**, 142.

A double iterative method for evaluating $y/x^{1/n}$ is derived, and it is shown that if $-1 \leqslant y^n < x < 1$, then it can be arranged that all terms occurring in the iteration are also within this range. The rate of convergence is then discussed and some special cases are mentioned.

12.8. GOWER, J. C. & RAYNER, J. H. (1958). Crystallographic programmes for the Elliott-N.R.D.C. 401 computer. *Brit. J. appl. Phys.* **9**, 446.

A brief description is given of programmes for the calculations involved in the X-ray analysis of crystal structures. The programmes calculate three-dimensional structure factors, one- and two-dimensional Fourier syntheses and R-factors.

12.9. HEALY, M. J. R. (1959). The effect of age-grouping on the distribution of a measurement affected by growth. *Amer. J. phys. Anthrop.* (In the press.)

Consider a measurement which is normally distributed at a fixed age and whose mean and variance increase linearly with age over a short period such as 1 year. If measurements taken over the whole period are pooled, the resulting distribution has the same mean as that of measurements taken at the central age, but the variance and higher cumulants are altered. Formulae are given relating the "pooled" values of the first four cumulants to the "instantaneous" values. The correction may be of importance in setting up standards of growth achieved at different ages.

12.10. HEALY, M. J. R. (1958). Variations within individuals in human biology. *Hum. Biol.* **30**, 210–218.

When a measurement on an individual is repeated, the two results do not usually agree exactly. The difference may result from inadequacy of the measuring technique or from real changes in the quantity measured. The paper discusses the assessment of this within-individual variation and its effect on estimates of variances, regression coefficients and correlations.

12.11. HEALY, M. J. R. (1959). Some basic statistical techniques in soil zoology. *Proc. int. Colloq. Soil Zool.* (In the press.)

This paper outlines a number of the basic techniques that are of use in soil zoological investigations. The general nature of statistical arguments is explained, and methods are described for estimating populations of soil animals, for investigating spatial distributions and for analysing counts from field experiments.

12.12. HEALY, M. J. R. (1959). Statistical Appendix to "A longitudinal study of the results of premature extraction of deciduous teeth between 3–4 and 13–14 years", by L. M. Clinch. *Dent. Practit.* (In the press.)

Successive annual measurements were taken on the dental arches of a number of children over the age range 3–4 to 13–14 years. Premature extraction of deciduous teeth is shown to result in a marked decrease in the width of the premolar-molar segment. The total space loss is related to the initial spacing between the teeth and, in the lower jaw, to the breadth of the permanent teeth.

12.13. LEECH, F. B. & HEALY, M. J. R. (1958). The analysis of experiments on growth rate. *Biometrics.* (In the press.)

A method is presented for the analysis of experiments in which successive measurements of the same quantity on the same organism are made at equal intervals of time. The specification and estimation of treatment effects are discussed, and the method is applied to an experiment on the growth rate of pigs.

When a treatment effect of degree p is specified, curves of degree p are fitted to the observations and it is shown that two estimates of each coefficient of the treatment effect are obtained from functions of the coefficients of these curves. The method of combining these estimates with minimum variance is shown. Thus when the treatment effect is linear in time, straight lines are fitted to the data and two estimates are obtained. A minimum variance combination of these gives an improved estimate of the treatment effect. The use of covariance analysis on the initial observations is also discussed.

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12.14. LEECH, F. B. & (SELLERS, K. C.) (1958). A second survey of losses associated with pregnancy and parturition in Yorkshire sheep. *J. agric. Sci.* (In the press.)

The results, as judged by returns for losses were similar to those observed in the first survey (Sellers & Leech, 1955), but the extra detail on the new questionnaire allowed a more critical analysis of some of the various categories of loss.

The results obtained are too numerous for an abstract, but two items of unusual interest were discovered. On arable farms the rate of abortion was 2·3 times greater in ewes bearing two or more foetuses than in ewes bearing a single foetus. There was no such differential rate under other forms of husbandry. The second item was a lower incidence of still-births than expected in ewes bearing two or more foetuses but not getting hay during pregnancy. Explanations of these results are offered which the authors suggested might be tested experimentally.

12.15. (LESLIE, P. H.) & GOWER, J. C. (1958). The properties of a stochastic model for two competing species. *Biometrika*, **45**, 316.

A stochastic model for studying by numerical methods the properties of the population variations of two competing species is described. Two varieties of this model have been programmed for the Elliott-N.R.D.C. 401 Computer in the Statistical Department at Rothamsted Experimental Station, and some of the results are given in the paper, together with a discussion on how these results are related to Parks' experimental observations on *Tribolium castaneum* and *Tribolium confusum*.

12.16. LIPTON, S. (1958). The evaluation of the bi-variate normal integral over a particular non-rectangular region. *Proc. Int. Congr. Mathematicians*, Abstracts of Short Communications, 1958, 161.

The integral of the bivariate normal distribution over an area defined by two exponential-type curves, arises in the development of a unified theory for quantal responses to drugs (Hewlett & Plackett, 1957, Nature, **180**, 712).

A method is described for evaluating this double integral using an empirical formula (due to C. Hastings, Jr.) for the uni-variate normal integral and Weddle's formula for the final integration. The merits of such empirical formulae and the steps taken to maintain accuracy and speed are briefly discussed.

The results, which were obtained using an electronic computer, were spot-checked with the help of a graphical method which yielded surprisingly high accuracy.

12.17. PATTERSON, H. D. (1958). The use of autoregression in fitting an exponential curve. *Biometrika*. (In the press.)

The simple regression of y_{x+1} on y_x has sometimes been used as an estimate of ρ in the equation

$$y_x = \alpha - \beta\rho^x$$

where $0 < \rho < 1$, $x = 0, 1, 2 \ldots n - 1$ and y_x are subject to independent errors with equal variance. An investigation by Dr. D. J. Finney, described in the same issue of *Biometrika*, showed that the estimate is of high efficiency and subject to a relatively small bias when $n = 4$. The present paper deals with the behaviour of the estimate for larger n. As n increases, the efficiency decreases markedly over the useful range of ρ, and the estimate is subject to an increasingly large negative bias. These properties invalidate the estimate.

Alternative estimates given by the regression of y_{x+1} on $ky_x + ly_{x+1}$ have also been considered. These estimates have the same asymptotic efficiency as the simple regression, but by a suitable choice of k/l the bias can be considerably reduced. They are, however, of only limited value, since in practice choice of k/l is difficult unless n is small.

The methods used to investigate the regression of y_{x+1} on y_x are suitable for a wide class of " quadratic " estimates of ρ (estimates of ρ in the form of a ratio of two quadratic functions of the y_x) defined in the paper.

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12.18. PATTERSON, H. D. & (LUCAS, H. L.) (1958). Extra-period change-over designs. *Biometrics*, **15**. (In the press.)

This paper deals with extra-period designs obtained by repeating the treatment pattern of the last period of any design in a general class of basic change-over designs. The basic designs are derived from Latin squares or incomplete Latin squares, and satisfy certain conditions of balance which facilitate the estimation of direct and first residual effects. The construction, analysis, efficiencies and uses of the extra-period designs are discussed in some detail.

12.19. (REEVE, E. C. R.) & GOWER, J. C. (1959). The effects of inbreeding when selection acts against homozygosis at one or more loci. *Proc. int. Symp. Biometr. Genet.* (In the press.)

Selection against homozygotes at certain loci is probably of general occurrence in normally outbreeding species, and will reduce the rate of progress towards homozygosity when such a species is inbred. A realistic theory of inbreeding must therefore take into account such effects.

Selection acting at a single locus will have both a direct effect on the speed of inbreeding at this locus and also indirect effects, through linkage, on points near it on the same chromosome. The direct effects have been investigated theoretically for all the standard inbreeding systems, but mathematical formulation of the linkage effects leads in most cases to very large generation matrices.

The simplest sib-mating case—equal selection against both homozygotes at one locus and its effect on a linked locus—which gives a 19×19 matrix, has been analysed with the help of an electronic digital computer, and the results are here compared with the corresponding situation under selfing.

A given selection pressure causes a relatively greater reduction in inbreeding speed at the locus directly affected, under sib-mating than under selfing, but the linkage effects are dispersed more rapidly as we move away along the chromosome, under sib-mating. This means that selection at one point on a chromosome has an effect which is locally more severe, but is also more localized in terms of the length of chromosome affected, under a milder than under a more rapid system of inbreeding.

Analysis of the effects of linkage to two loci each carrying only recessive lethals, in the two systems, suggests that selection against homozygosity at several points on the same chromosome will tend to sharpen the differences in inbreeding speed between different systems in the neighbourhood of these points, and to lessen these differences at loci in intermediate regions.

12.20. (SPICER, C. C.) & LIPTON, S. (1958). Numerical studies on some contagious distributions. *J. Hyg. Camb.* **56**, 516–522.

A numerical investigation of three contagious distributions of epidemic data has been made using an electronic computer. All three show a modified threshold effect such that the proportion of a community affected tends to 100 per cent as its size increases, though there is no abrupt change of form.

12.21. WESTMACOTT, M. H. (1958). Rearing dairy heifers on different planes of nutrition: an interim report on three experiments. *Exp. Husb.* (In the press.)

Three experiments on the rearing of autumn-born heifers are described, and tables of growth rates and body weights up to 2 years of age are presented.

A moderate plane of nutrition in the first and/or second winter of the life of the heifers depressed conception rates at 15 months old compared with a high plane of nutrition; after a further year there was little difference between conception rates. In general, it was the lighter animals in each treatment group which failed to conceive.

12.22. YATES, F. & REES, D. H. (1958). The use of an electronic computer in research statistics: four years' experience. *Comp. J.* **1**, 49–58.

An electronic computer has now been in operation for four years in the Statistics Department of Rothamsted Experimental Station. This paper gives an account of the experience gained in applying the computer to statistical problems arising in agricultural and biological research.

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12.23. (BLOOD, J. W. *et al.*), BOYD, D. A., CHURCH, B. M., HILLS, M. G. & SIMPSON, H. R. (1958). The survey of fertilizer practice, 1957. Part II. (Ministry of Agriculture Duplicated Report.)

12.24. BOYD, D. A. & LESSELLS, W. J. (1958). The N.A.A.S./N.I.A.B. variety trials 1955–57: the effect of nitrogen and its interaction with variety. Preliminary report.

12.25. BOYD, D. A. (1958). Field experiments on the correlation of soil analysis with crop response to fertilizers. First and Second Reports.

12.26. (YEO, D.) & SIMPSON, H. R. (1958). The effect of repeated insecticidal applications on a natural tsetse population. *Colon. Pesticides Res. misc. Rep.* 207.

Woburn Experimental Station

15.1. MANN, H. H. (1958). Effect on yield of undersowing winter grain. *Agriculture, Lond.* **65**, 419–420.

In an experiment at Woburn, there was little difference in the crops of grain (winter wheat and winter rye) when undersown with a clover seeds mixture, as compared with similar grain crops when not undersown.

15.2. MANN, H. H. (1958). Field studies in green manuring. I. *Emp. J. exp. Agric.* **26**, 274–282.

In experiments carried out for 6 years on light soil at Woburn, comparisons were made between lupins, vetches and mustard as green manure crops. The effects of removing the whole crop, or burying the roots only, or burying whole plants, or burying whole plants plus extra tops, were measured by the yield of a kale crop grown immediately after burying the green manure crop.

Green-manure crops had appreciable manurial value when utilized at once. It is important, therefore, that the crop which is intended to benefit should be grown very soon after the green manure is buried in soil conditions favourable for its rotting.

Beneficial results were not directly related to the amount of nitrogen, nor of organic matter in the buried material. There is some relationship in each case, but it is complex and obscure. Little or no benefit resulted from growing a green crop and then removing it, or from leaving only the roots. Burial of the whole crop, with or without extra tops, gave similar beneficial results with both legumes, but the effects with mustard were variable.

15.3. MANN, H. H. (1959). Field studies in green manuring. II. *Emp. J. exp. Agric.* (In the press.)

An account is given of investigations continued at Woburn with the object of determining the factors which control the efficiency of green manures. Relevant factors studied were the effects from additions of farmyard manure, or straw, or nitrogenous fertilizers applied when the green manures were buried. The green manures used were either grown in the spring (vetches, lupins, mustard, rape), or undersown in the previous crop of barley (clover, ryegrass). In all cases, the green-manure crop was buried by ploughing, in June or July, and followed almost at once by the sowing of kale or the planting of winter cabbages, which served as test crops.

Earlier results were confirmed, in so far as the immediate effect of a green manure was not to any great extent determined by the amount of green matter buried, but there was a remote connection between the amount of nitrogen buried and the efficiency of the green manure.

The addition of farmyard manure to the green manures did not materially affect their efficiency, whilst the addition of straw was disadvantageous.

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Additions of nitrogenous fertilizer at time of burial increased the efficiency of the green manures.

After a period of 18 years, the effects on nitrogen and organic-matter status of the soil were greater in the cases of those green manures which were undersown in the previous crop of barley.

Dunholme Field Station

General Papers

16.1. Adams, S. N. (1958). Sugar-beet fertilizer experiments in 1957. *Min. Agric. Sug. Beet Res. & Educ. Comm. Pap.* **489.**

16.2. Byford, W. J. (1958). *Phytophthora verrucosa* on Dahlia. *Plant Path.* **7, 38.**

16.3. Cornford, C. E., Dunham, E. C. W., Dunning, R. A., Gates, L. F. & Hull, R. (1958). Sugar-beet disease investigations, 1957–58. *Min. Agric. Sug. Beet Res. & Educ. Comm. Pap.* **486.**

16.4. Cornford, C. E. (1958). Oospores of *Peronospora schachtii* found in England. *Plant Path.* **7, 38.**

16.5. Cornford, C. E. (1958). Perfect stage of *Phoma betae* found in England. *Plant Path.* **7, 113.**

16.6. Hull, R. (1958). Sugar-beet yellows in Great Britain, 1957. *Plant Path.* **7, 131.**

16.7. Hull, R. (1958). Sugar-beet yellows. The search for control. *Agriculture, Lond.* **65, 62–65.**

16.8. Hull, R. (1958). Sugar Beet. A crop in peril. *Fmrs Weekly*, **48,** Sugar Beet & Potato Suppl., 13–14.

Research Papers

16.9. Dunning, R. A. (1957). Stem eelworm invasion of seedling sugar-beet and development of crown canker. *Nematologica*, **2** (Suppl.), **362–368.**

Literature on the host range of the race of stem eelworm concerned, the symptoms of crown canker, effect on yield and the distribution of attacks in Europe is reviewed. Serious attacks most often develop as a result of eelworms from the soil invading seedlings. The infested seedlings show distinct symptoms. When invaded early they become " blind " and later grow into multiple-crowned plants. Severe canker develops in the autumn in plants invaded as seedlings. Slight canker can develop when plants are invaded during the summer and early autumn. Mangolds are more susceptible than sugar beet to eelworm invasion and to canker.

16.10. Gates, L. F. (1958). Experiments on black leg disease of sugar-beet seedlings. *Ann. appl. Biol.* **47.**

Soaking sugar beet seed for 20 minutes in ten times its weight of water containing 40 p.p.m. ethyl mercury phosphate to control seed-borne *Phoma betae* gave better seedling emergence than surface treatments with commonly used organo-mercury dusts or with " Panogen ", thiram, " Granosan M ", " Captan ", " Dow 9B " or " Cerenox ". In 4 years' field trials, soaking seed in ethyl mercury phosphate solution, followed by dusting with an insecticidal dust, compared with a routine, combined mercury plus insecticidal dust, increased seedling emergence at fifty-three of fifty-nine sites by an average of 10 per cent under good emergence conditions and by 20–30 per cent under adverse conditions. Final plant stand was increased each year by an average of 5·8, 3·4, 1·8 and 0·6 per cent respectively.

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16.11. GATES, L. F. (1958). Seed and soil treatment with systemic insecticides to prevent aphid colonisation of emerging sugar-beet seedlings. *Ann. appl. Biol.* **47.**

When 2 lb. " Hanane " or 1 lb. " Thimet " were applied at drilling in 100 gallons water along the drills, or seed was treated at rates to apply 6–8 oz. " Thimet " or 8–24 oz. " Disyston "/acre, sugar-beet seedlings were toxic to aphids 30 days after planting four April–May-sown root crops, and 30–40 days after planting five autumn-sown steckling crops. Germination was 73–100 per cent after soil treatments, 91–98 per cent after " Disyston " seed treatments and 62–84 per cent after " Thimet " seed treatments. The treatments slightly reduced *Aphis fabae* injury to stecklings in 1955 and the number of plants with yellows in a steckling experiment in 1956.

Soil Survey of England and Wales

17.1. *The county of Anglesey—soils and agriculture.* London: H.M. Stationery Office, 1958.

17.2. *Soil map of the Lleyn Peninsula. Sheet 119* (7th Edn.). Southampton: Ordnance Survey, 1958.

17.3. ASHLEY, G. D. & WILKINSON, B. (1958). Observations on restored opencast coal sites. *N.A.A.S. quart. Rev.* (In the press.)

17.4. OSMOND, D. A. (1958). Micropedology. *Soils & Fert.* **21**, 1–6.

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