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Rothamsted Research

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PUBLICATIONS

Physics Department

1. RUSSELL, E. W. 1948. *Deep tillage*. Agric. Eng. Record, 2, 70-73.

Deep tillage should only be practised on drained land. If the field has a drainage system already installed, or has a naturally free-draining subsoil, deep tillage will often increase the speed of drainage. There is an indication not yet well established that deep ploughing is rather more efficient than subsoiling for this purpose.

Deep ploughing usually gives a better control of weeds in the early part of the growing season, and in consequence may allow spring-sown crops to be planted earlier with less loss of water from the seed bed than is possible on shallow ploughed land.

Deep ploughing enables the depth of fertile soil to be increased. It has not yet been possible to demonstrate rigorously under what conditions this extra depth results in increased yield.

Provided that adequate fertilizer is added to the seed bed to ensure that it is not too poor, that the field is well drained, and that the subsoil does not consist of broken pieces of limestone or large lumps of solid chalk, there is no indication that deep ploughing will depress crop yields no matter what kind of sand or clay is brought up. It is not therefore a dangerous operation under the conditions specified.

2. PENMAN, H. L. 1948. *Evaporation in nature*. Reports on Progress in Physics, 11, 366-388.

After a historical survey of the problem, an outline is given of the theoretical approaches that have been made, including the various forms of aerodynamic theory and the energy balance method. Then follows a review of available information on evaporation from open water, bare soil and cropped land, including catchment areas.

3. SCHOFIELD, R. K., and PENMAN, H. L. 1949. *The principles governing transpiration by vegetation*. Proc. of Conf. on Biology and Civil Engineering (Institution of Civil Engineers, Sept. 1948, 75-84).

The amount of drainage from soil over a period is the amount of precipitation that is not transpired by growing vegetation or lost by evaporation from bare soil. The main source of the necessary latent heat of vaporization is sun and sky light and hence the total evaporation from a given area of vegetation is dependent upon the acreage rather than upon the integrated leaf area.

For evaporation from open water it is possible to relate the evaporation rate to external weather conditions, and direct comparison of equal areas of open water and plentifully watered grass shows that the latter too is controlled by the same external conditions. Because of leaf structure and seasonal changes in day-length, the transpiration rate from grass is less than the evaporation rate from open water by about 20 per cent. in summer, 40 per cent. in winter, and 30 per cent. in equinoctial months.

During the growing season the moisture deficit in the soil will increase at a rate dependent upon the drying power (determined by weather) and the seasonal factor until the root range of the crop becomes a limiting factor. After the deficit reaches a value of C inches, depending upon soil type and depth of rooting, further increase takes place at progressively lower rates. Examination of available data indicates that C has a value of about 3 inches for grassland in Britain, and in particular, the calculated values of evaporation from the grassland of the Cambridge University Farm, based on values of C of this order, are checked by direct observation of the soil moisture and by the recorded dates on which the field drains started to run.

Minor factors may cause local disturbances, such as cracks in dry soil, rising soil temperature which may produce slight drainage, and poor natural structure which may delay drainage. The last will often occur in sandy and similar soils without coarse drainage channels produced by swelling and shrinking, drainage being very slow and almost continuous. Although precise specification of times of zero moisture deficit is not possible on such soils, an arbitrary specification, that will meet ordinary practical requirements, will often be possible.

4. PENMAN, H. L. 1948. *Physics in agriculture*. J. Sci. Inst., **25**, 425-432.

Two fundamental problems in farming are discussed. In the first it is shown that application of thermodynamic reasoning has led to a clarification and deeper understanding of the nature of the equilibrium between the soil and its water content, has demonstrated the limited extent of possible water movement, and has provided an interpretation of the results of cultivation experiments which revealed that weed control is the all important justification for inter-row cultivation. In the second, diffusive processes and energy transformations are shown to account quantitatively for the rate of transpiration of growing crops, and from a knowledge of weather conditions it is possible to control the amounts and times of application of irrigation water.

5. PENMAN, H. L., and LONG, I. 1949. *A portable thermistor bridge for micro-meteorology among growing crops*. J. Sci. Inst., **26**, 77-80.

Using thermistors, supplied by Standard Telephones and Cables Ltd., a portable unit has been built to measure temperature, humidity, and wind speed among growing potato crops in connexion with an investigation into factors affecting the spread of virus disease.

Type F thermistors are used as resistance thermometers for measuring dry- and wet-bulb temperatures: type L, with the glass sheath removed, is used to measure wind speed on the hot-wire anemometer principle. For the latter, the response has been found to depend upon ambient temperature, but by including another thermistor in the bridge circuit, complete compensation has been achieved over a temperature range from 13° to 30°C.

6. SCHOFIELD, R. K. 1949. *Effect of pH on electric charges carried by clay particles*. J. Soil Sci., **1**, 1-8.

A method is described for obtaining the net charge carried by a clay in equilibrium with an ammonium-chloride solution of known pH.

A measure is also obtained of the variation with pH of the chloride adsorption.

Results are reported for a sample of subsoil clay both untreated and also after repeated treatment with acid ammonium oxalate in sunlight.

A component consisting mainly of hydrous ferric oxide is dissolved away by the acid ammonium oxalate. It carries positive charges at pH 3, but not at pH 7.

The clay mineral in this subsoil is mainly of the illite type, and is not attacked by the acid ammonium oxalate. It carries a constant negative charge between pH 2.5 and pH 5, due presumably to isomorphous replacement. Additional negative charges develop with rise in pH above 6.

This subsoil does not contain a 'clay acid' comparable in strength to acetic acid. The buffering exhibited by the acid-washed clay below pH 6 is attributed to the precipitation as aluminium hydroxide of exchangeable aluminium ions.

7. SCHOFIELD, R. K., and TALIBUDDIN, O. 1948. *Measurement of internal surface by negative adsorption*. Discussions of the Faraday Soc., No. **3**, 51-56.

An extension of Gouy's treatment gives the equation

$$\frac{\Gamma_-}{n} = \frac{q}{\sqrt{v\beta n}} - \frac{4}{v\beta\Gamma}$$

for the negative adsorption Γ_- of the repelled ions in the diffuse part of the electric double-layer. The conditions under which this equation can be applied and the errors that may arise in non-ideal conditions are set out.

Measurements have been made at pH 6 and pH 1.3 of the small increase in concentration occurring when samples of jute are shaken up in chloride solutions, the concentration, n , ranging from N to $N/128$. At pH 1.3 the volume $v_{1.3}$ of water taken by 100 gm. of dry jute is close to 11 c.c. for concentrations below $N/10$. This water is presumably taken into the fibre substance where chloride ions cannot enter. At pH 6 the volume v_6 is greater than $v_{1.3}$. The difference, v_E , must be due to the influence of the negatively charged groups. Their amount, E , was determined for each of the three samples of jute by cation exchange. The limit, V , of v_E as $n \rightarrow 0$ is the volume of the pore space which ranges from 50 to 75 c.c. per 100 gm.

In the case of two samples of "red" jute all the conditions for the application of the equation were fulfilled over a sufficient range of concentration for

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the equivalent plane area, A , of the internal surface to be obtained from the slope of the graph of v_E against $q/\sqrt{v\beta n}$. It is roughly a thousand times the external surface of the fibres. In the case of a sample of "white" jute the conditions are not fulfilled, and the results follow Donnan's equation for the membrane equilibrium. In the "red" jute the average separation of negative (mainly —COO^-) groups on the internal surface is about 12 A., and the average width of the pore space is about 100 A. In the "white" jute the groups are at least 25 A. apart on the surface and the average width of the pore space does not exceed 50 A.

8. SCHOFIELD, R. K., and DAKSHINAMURTI, C. 1948. *Ionic diffusion and electrical conductivity in sands and clays*. Discussions of the Faraday Soc., No. 3, 56-61.

A technique has been developed for measuring separately the diffusion coefficients of the cations and anions of a salt solution. Knowing these coefficients, measurements of ionic diffusion give the effective fractional area of the water channels in porous systems ranging from glass beads through sands to fine clays.

In the clay systems there are more cations than anions owing to the negative charges on the particles. Taking this into consideration, the electrical conductivities are found to be concordant with the diffusion measurements.

The conductivity of N./10 KBr solution is reduced 16 per cent. by adding 0.91 per cent. of a very fine bentonite which, under these conditions, forms a thixotropic gel, whereas the conductivity of N./40 KBr is increased 3 per cent. by adding 0.57 per cent. of the same bentonite which in this case forms a deflocculated suspension devoid of rigidity. These bentonite particles are plates 10 A. thick.

These results strongly support the view that the bentonite particles in a thixotropic gel form a kind of network in which the edges of neighbouring particles are drawn towards each other.

OTHER PAPERS

- 8a. SCHOFIELD, R. K. 1947. *The measurement of evaporation*. Comptes Rendus du Congres de Pedologie (Montpellier—Alger), 85-86.
8b. RUSSELL, E. W. 1947. *Current problems in soil cultivation*. Comptes Rendus du Congres de Pedologie (Montpellier—Alger), 93-96.

Chemistry Department

9. RICKSON, J. B. 1948. *A semi-micro combustion method for determination of organic carbon*. Analyst, 73, 268-274.

A modification of the Ter Meulen combustion method for the determination of organic carbon is described, incorporating a new type of vessel for the absorption of carbon dioxide in barium hydroxide solution, with subsequent titration of the excess of absorbent. The apparatus permits of the estimation of 2 to 6 mg. of carbon, with a maximum error of 1 per cent. of the quantity determined.

10. HEINTZE, S. G., and MANN, P. J. G. 1949. *Studies on soil manganese, Part 1. Pyrophosphate as extractant of soil manganese*. J. Agric. Sci., 39, 80-95.

A method for estimating divalent manganese in neutral pyrophosphate was developed from the dismutation reaction:



It was shown that the manganese of alkaline pyrophosphate extracts from soils with low organic matter was in the divalent form. The reverse dismutation reaction may occur in neutral pyrophosphate, and the presence of trivalent manganese in such extracts cannot therefore be taken as proof that trivalent manganese existed in the soil. Since pyrophosphate extracts of organic soils reduce manganese dioxide, the presence of divalent manganese in such extracts cannot establish the presence of divalent manganese in soils. Manganese added in neutral pyrophosphate is taken up by organic soils in a form which is not readily exchangeable by other cations but which can be recovered in pyrophosphate at pH 9.4. Only a small part of the manganese taken up by organic soils in the presence of ammonium acetate can be recovered by subsequent extraction with ammonium acetate, but the recovery is

markedly increased on adding small amounts of salts of several heavy metals. Manganese and copper combined with organic matter could be extracted from soils by first saturating the soils with sodium and thus extracting, in turn, with water, sodium pyrophosphate and sodium hydroxide.

The hypothesis is advanced that part of the manganese of neutral and alkaline organic soils is present as complexes with the organic matter.

11. COOKE, G. W. 1949. *Placement of fertilizers for potatoes*. J. Agric. Sci., **39**, 96-103.

In 29 experiments conducted in 1945, 1946 and 1947 placement of fertilizer in contact with the seed or in two bands each two inches below the level of the seed gave average yields similar to those given by the standard practice of broadcasting after ridging but before planting. Placement in one band two inches below the seed was tested in four experiments and proved inferior to other placement methods and to broadcasting over the ridges.

Broadcasting fertilizer before ridging was compared with broadcasting after ridging in 25 experiments in 1946 and 1947. Applications made after ridging were consistently superior to those made before ridging. The general relationship was that 10 cwts. of fertilizer per acre broadcast before ridging were required to produce average increases in yield equal to those given by 7 cwts. per acre broadcast after ridging.

Observations on the growing crops revealed no harmful effects of fertilizer placed in contact with the seed in 1945 and 1946. In 1947, however, at several centres growth was severely checked by heavy dressings placed in contact with the seed and the final yields were below those from fertilizer placed in sidebands, which caused no early check.

12. CROWTHER, E. M. 1947. *The study of soil organic matter and organic manures by means of field experiments*. Comptes rendus de la Conference de Pédologie Méditerranéenne, Montpellier and Algiers, 123-139.

A discussion of the balance between cultivating and resting land and of the use of bulky organic manures is illustrated by the results of soil analyses from long-continued manurial experiments at Rothamsted, Woburn and Lyngby, Denmark. In all three experiments the increase in soil nitrogen on the farmyard manure plots over the unmanured plots amounted to about 30 per cent. of the nitrogen added in the farmyard manure, when approximately steady states had been reached in from 25 to 50 years. Some modern attempts to analyse the effects of organic manures and leys by means of field experiments are described. These include a series of potato experiments at Rothamsted on factorial combinations of fertilizers and farmyard manures, a rotation experiment on arable crops, lucerne and grazed leys at Woburn, and an experiment at Serere, Uganda in which resting under grass gave definitely better soil structure than resting under green manure crops; farmyard manure had negligible effects on soil structure.

13. CROWTHER, E. M. 1948. *The manuring of potatoes*. J. Royal Agricultural Society, **109**, 114-117.

The results of field experiments at Rothamsted and many other centres are reviewed in relation to current problems.

14. CROWTHER, E. M. 1948. *Fertilizers during the war and after*. Bath and West and Southern Counties Society, Pamphlet No. 13, Second Edition.

The principles of manuring are reviewed in relation to wartime practice and current problems. A complete resetting of the pamphlet for the second edition allowed the results of recent investigations and statistics for the consumption of fertilizers to be included.

15. CROWTHER, E. M. 1948. *Fertilizers in the agricultural expansion programme*. Agriculture, **54**, 491-500.
16. CROWTHER, E. M. 1948. *Fertilizer Practice, 1939-1948*. Journal Institute Corn and Agricultural Merchants, Ltd., 143-148.
17. CROWTHER, E. M. 1947. *Soils and fertilizers*. J. Royal Agric. Soc., **108**, 69-81.

Pedology Department

SCIENTIFIC PAPERS

18. MACÉWAN, D. M. C. 1948. *Complex formation between montmorillonite and halloysite and certain organic liquids*. Trans. Faraday Soc., **44**, 349-67.
(Work partly carried out at Macaulay Institute for Soil Research, Aberdeen).

Adsorption complexes formed by neutral organic molecules with montmorillonite and halloysite are described. The molecules are found to lie in parallel layers between the structural sheets of the clay mineral, probably in the form of a two-dimensional liquid; with one exception, they lie as flat as possible. With montmorillonite one, two and three layers are found, with halloysite only one.

It is shown that the C-O distances in the halloysite complexes decrease with increasing electronegativity of groups attached to C, thus providing confirmatory evidence of Bradley's suggestion that CH-O bond formation occurs.

The relationship of this type of adsorption to surface adsorption is discussed; and its value in determining questions of molecular configuration exemplified.

19. MACÉWAN, D. M. C. 1948. *Clay mineral complexes with organic liquids*. Clay Minerals Bulletin, 36-7.

A summary of previous work is given. It is shown that the number of layers in montmorillonite complexes runs roughly parallel with the value of $\mu [P]$, where μ = dipole moment of organic molecule, and $[P]$ = Sugden's parachor.

20. MACÉWAN, D. M. C. 1948. *Adsorption by Montmorillonite, and its relation to surface adsorption*. Nature, **162**, 935-6.

It is suggested that the intra-crystalline swelling of montmorillonite is connected with a repulsive force between the structural sheets, arising from adsorption of layers of neutral molecules. Bangham and Mosallam's adsorption isotherms for mica are used to calculate a probable value of the energy changes involved in adsorption of methanol and it is shown that balancing these against the attractive van der Waals energy (using Vervey and Overbeek's formula) cannot explain the equilibrium which is actually observed, with reasonable values of the constants. It is suggested, therefore, that there is another type of attractive force between the montmorillonite sheets, perhaps electrostatic (involving the exchangeable ions).

21. MACÉWAN, D. M. C. 1949. *Some notes on the recording and interpretation of X-ray diagrams of soil clays*. Soil Sci., **1**, 90-103.

The general notes contained in this paper consist of:

- (a) A brief description of the type of diffraction camera now used in the Pedology Department for clay mineral work, and a discussion of the requirements to be satisfied by such a camera.
(b) A description of a device for making cylindrical specimens of constant radius, together with formulae for suitable binding media.
(c) A note on the significance of the general ($h k$) or ($h k l$) reflections from clay minerals, especially of the (06) and (060) reflections.
(d) A discussion of the various types of scattering near the centre (equivalent spacing greater than 20A) which can be observed with clay minerals. Such scattering is probably due to interpolations in the structure (hydration or "chloritization"—interpolated layers of iron or aluminium hydroxide), and different types of central scattering are observed according as such interpolations are (1) regular, (2) random, or (3) localised.

OTHER PAPERS

22. MUIR, A. 1948. *Some recent developments in soil survey and pedology*. Agric. Progress, **22**, 99-105.

Microbiology Department

23. LEES, H., and MEIKLEJOHN, J. 1948. *Trace elements and nitrification*. Nature, **161**, 398.

Experiments with enrichment cultures of nitrifying bacteria in a liquid medium gave the following results: (1) Iron had a stimulating effect on nitrite formation. (2) A trace element mixture without iron, copper or

zinc had an inhibiting effect. (3) This inhibition was removed by iron or copper, but not by zinc. (4) The trace element mixture with both iron and copper, or iron, copper and zinc, had a stimulating effect.

24. SINGH, B. N. 1948. *Studies on giant amoeboid organisms*. 1. *The distribution of Leptomyxa reticulata Goodey in soils of Great Britain and the effect of bacterial food on growth and cyst formation*. J. Gen. Microbiol., **2**, 8-14.

Giant amoeboid organisms may be isolated from soil and other materials by the use of suitable edible bacteria supplied on a base of non-nutrient agar. *Leptomyxa reticulata* is widely distributed in the soils of Great Britain. The common occurrence of this organism in soils which have been unmanured or treated with artificial fertilizers for 100 years or more proves that it is a soil inhabitant.

Degrees of pH between 4.1 and 8.7 had no effect on the abundance of growth when a suitable bacterial strain was supplied as food on non-nutrient agar.

Ninety-two very varied strains of bacteria tested as food for *L. reticulata* varied greatly in edibility. Bacteria producing red, violet and blue pigments were mostly inedible. There was no correlation between Gram-staining and edibility.

Certain bacterial strains induced the formation of cysts by *L. reticulata*. This property was not correlated with their edibility.

25. SINGH, B. N. 1948. *Studies on giant amoeboid organisms*. 2. *Nuclear division and cyst formation in Leptomyxa reticulata Goodey with remarks on the systematic position of the organism*. J. Gen. Microbiol., **2**, 89-96.

Excellent cytological preparations may be made from growth of *Leptomyxa reticulata* on cover-slips on a film of agar.

The organism is multinucleate. Each resting nucleus contains a deeply staining mass, the nucleolus, which is surrounded by a clear zone in which chromatin material is scattered. There is always a definite nuclear membrane. The nuclei divide simultaneously by intranuclear mitosis and the whole process is completed in a short time. At prophase the dispersed chromatin granules aggregate and later assume a thread-like structure and enter upon the metaphase. The formation of the spindle can be seen at the beginning of the metaphase. No centrosomes are seen at any stage. During anaphase the chromosomes begin to separate and it is difficult to count their numbers. The nuclear membrane disappears at late anaphase. At telophase the daughter chromosomes fuse together, the connecting threads break and the daughter nuclei are formed.

Under suitable cultural conditions and on certain strains of bacterial food supply, multinucleate cysts are produced in clusters. The process of cyst formation is described.

26. ANSCOMBE, F. J., and SINGH, B. N. 1948. *Limitation of bacteria by micro-predators in soil*. Nature, **161**, 140.

Eighty-seven strains of very varied bacteria were tested on the following eight micro-predators: two unidentified species of soil amoebae, a giant amoeboid organism (*Leptomyxa reticulata*, Goodey), myxamoebae of two species of Dictyostelium (*D. mucoroides* and *D. giganteum*) and three species of Myxococcaceae (*Myxococcus virescens*, *M. fulvus* and *Chondrococcus exiguus*). The first five organisms are holozoic; the Myxococcaceae destroy and digest their food by means of secretions. The two soil amoebae reacted very similarly to their bacterial prey; that is, nearly all bacteria edible to one amoeba were edible to the other. Similarly, the myxoamoebae of the two *Dictyostelium spp.* were very similar in their food preference as were also two of the myxobacteria, namely *Myxococcus fulvus* and *Chondrococcus exiguus*. Out of the eight micropredators five show some tendency, but not a very pronounced one, to feed on the same selection of host bacteria; whereas the remaining three predators are each highly correlated with one of the five, and so not likely to affect appreciably the total number of bacterial strains edible to one or more of the predators.

Dictyostelium giganteum, *D. mucoroides*, *Myxococcus fulvus* and *Chondrococcus exiguus* prefer bacterial strains that are Gram-negative. The remaining predators do not show any such preference to Gram-reaction.

27. NUTMAN, P. S. 1948. *Physiological studies on nodule formation. 1. The relation between nodulation and lateral root formation in red clover.* Ann. Bot. **XII**, 81-96.

The rates of formation of both lateral roots and nodules are determined by the same hereditary host plant factors. A high rate of nodulation is associated with a high rate of emergence of laterals and not to a more extensive root system.

Uninoculated plants at first produce more lateral roots than uninoculated plants, independently of the effectivity of the strain of bacteria used as inoculum. With effective strains of bacteria the numbers of laterals exceed the numbers of nodules due to the secondary production of roots following nitrogen fixation in the nodules. With ineffective strain inoculation the number of nodules exceed the number of laterals. With either strain, under the conditions of experimentation employed, the sum of lateral roots and nodules finally approach the same value. With an effective strain delay in inoculation leads to an enhanced rate of nodule formation.

The results suggest that lateral roots and nodules are physiologically homologous, the infection of the root taking place only at pre-determined foci corresponding to the sites of initiation of lateral roots. It is also suggested that the production in the nodule and root meristem of substances inhibiting development at these foci may account for strain differences in rates of nodule formation.

28. JONES, P. C. T., and MOLLISON, J. E. 1948. *A technique for the quantitative estimation of soil micro-organisms.* J. Gen. Microbiol., **2**, 54-69.

Soil micro-organisms have been counted by a new technique whose essential feature is the suspension of measured amounts of soil in a molten agar gel from which small drops are removed and allowed to solidify as thin films on a haemocytometer slide of known depth. The instantaneous gelation of the agar ensures the fixation of the soil constituents in their original distribution. The films are dried and stained in a solution of acetic-aniline blue and permanent preparations made by subsequent dehydration in ethanol and mounting in euparal. If the suspension is of known dilution, since films of a definite volume contain a known quantity of soil, differential counts of a measured area of film will yield a quantitative estimate of soil micro-organisms.

The distribution of bacteria per microscopic field was found to be complex. The frequencies of bacterial colonies and of pieces of fungal mycelium form a Poisson series; those of the number of bacteria per colony form a logarithmic series; and those of the total number of bacteria per field fall into a negative binomial distribution.

The method appears to be capable of modification by the use of selective nutrient media for determining the quality of the microflora and possibly the percentage viability of the organisms present.

29. JONES, P. C. T. 1948. *The microbial decomposition of resinous stabilising agents in soil.* Proc. 2nd Int. Conf. Soil Mechanics & Foundation Engineering. Rotterdam, **4**, 280-284.

In connexion with the stabilisation of soils for road beds with resinous materials a study has been made of the resinolytic organisms present in natural soils. Techniques of isolating and counting these organisms have been developed, using enrichment cultures and agar media in which the appropriate resin is colloiddally dispersed as a sole available carbon source. The resins are dispersed after saponification into a buffer solution and provide an opaque plating medium on which resin decomposition may be detected by the 'halation' produced by resin digesters.

Using such media, a number of resin-attacking bacteria and fungi (notably *Aspergilli*) have been isolated from all the soils studied and the more active isolates shown to attack resins both *in vitro* and in soil. These organisms have been diverse and have included proactinomycetes, pseudomonads and other eubacteria, and *Aspergilli*.

Resin stabilised soil specimens were inoculated with resin-attacking organisms, and the relation between the relative increase in the numbers of the latter and the subsequent breakdown of the specimens was observed.

A search for remedial antiseptics was then made and it was found that mercuric chloride was particularly effective.

30. JONES, P. C. T., and MOLLISON, J. E. 1947. *Estimation of the number of bacterial cells in soil by direct examination.* Fourth Int. Cong. Microbiol. Copenhagen.

31. NUTMAN, P. S. 1947. *The interaction of hereditarily determined strain and host factors in symbiosis*. Fourth Int. Cong. Microbiol. Copenhagen.
32. SINGH, B. N. 1947. *The biology of Myxococcaceae from soil*. Fourth Int. Cong. Microbiol. Copenhagen.
33. THORNTON, H. G. 1947. *The biology of strains of Rhizobium*. Fourth Int. Cong. Microbiol. Copenhagen.

Botany Department

34. LONG, H. C., and BRENCHLEY, W. E. 1949. *Suppression of weeds by fertilizers and chemicals*. (3rd, enlarged edition.)
35. BRENCHLEY, W. E. Review of *Koper als onmisbaar element voor plant en dier*. (Wageningen.) Review in Nature, 1948, 161, 624.

Statistics Department

BOOK

36. YATES, F. 1949. *Sampling methods for censuses and surveys*. Griffin & Co., London, 318 pp.

This book has been written primarily for those who have little or no previous training in mathematical statistics, but who have some training or experience in the presentation and handling of statistical data. Although not a mathematical treatise, an attempt has been made to cover all the modern developments of sampling theory which are of importance in census and survey work, and to give an adequate discussion of the complexities that are encountered in their practical application. The preparation of the book revealed a number of gaps in current theory which had to be filled in. The book should therefore also be of interest to mathematical statisticians.

The various computational procedures have been illustrated, as far as practical, by numerical examples. These examples in the main have an agricultural background, since this type of data was most readily accessible and is also particularly relevant to the original purpose of the book. For the most part the data on which they are based form a small part of the results of much larger surveys.

The preparation of the book was undertaken at the request of the United Nations Sub-Commission on Statistical Sampling in connection with the projected 1950 World Census of Agriculture and the 1950 World Census of Population.

SCIENTIFIC AND TECHNICAL PAPERS

37. BOYD, D. A. 1949. *Experiments with leys and permanent grass*. J. Brit. Grassl. Soc., 4, 1-10.

The paper discusses some general questions affecting the design and technique of experiments on grassland. Experimental results are quoted which emphasize the importance of choosing a uniform site for experiments and of employing adequate replication. It is suggested that the experimenter can best fulfil these requirements by reducing plot-size and that he should aim at plots of the order of $\frac{1}{4}$ acre even at the expense of some artificiality in the grazing management. Small plots should also enable him to include a more comprehensive range of treatments and to gain advantage of factorial design. The value of grasscutting as a check on grazing management and to allow a further reduction in plot-size is examined. The application of these principles is illustrated from the design of a new experiment being laid down at Rothamsted.

38. PATTERSON, H. D. 1948. *Sampling on successive occasions with partial replacement of units*. J.R. Statist. Soc., Series B. (In the press).

If the characteristics of a population under survey alter with time it is often necessary to have estimates of these characteristics on a number of occasions and of the rate of change. Means of the separate occasions can best be estimated if the sampling is arranged so that successive occasions are sampled by units a number of which are in common. Assuming a law in which the correlation between observations on a single unit on different occasions are $\rho, \rho^2, \rho^3, \dots$ for occasions 1,2,3, . . . apart and assuming that the value of the correlation is known, expressions are derived for the efficient estimates of the mean on any occasion and differences between means, with their variances. These expressions are derived by the application of certain properties of estimates having minimum variance. In certain cases the computation involved in the calculation of the fully efficient estimates

is heavy. It is shown that little information is lost in using simpler estimates, the most important of which are included in the discussion by Yates (1949) of the problem. The general case in which there may be unequal numbers of units, unequal variances and different fractional replacements from occasion to occasion is developed. The effects of departure from the above correlation law and of inaccuracies in weighting are also considered.

39. READ, D. R., and GREGORY, P. H. 1949. *The spatial distribution of insect-borne plant virus diseases*. Ann. appl. Biol., **36**. (In the press.)

Various workers have proposed formulae to express the spatial distribution of insect-borne diseases. All the published data examined, as well as the Rothamsted data for rugose mosaic and leaf roll in potato crops, were fitted as well by the simple empirical expression $\log I = a + b x$ as by more complex expressions ($I =$ number of infective punctures at a distance x from the source after a given time, and a and b are constants for any one given set of field conditions). It is suggested that distances should always be given in metres, in order to give comparable results from one investigation to another. In the analysis of data on rugose mosaic and leaf roll in different years, it is shown that a and b vary independently.

40. YATES, F. 1949. *Design of rotation experiments*. Proceedings of the Commonwealth Agricultural Bureaux Conference on Tropical and Sub-Tropical Soils. Commonwealth Bur. Soil Sci. Technical Communication No. 46, 142-155.

The design of rotation experiments introduces a number of new problems not met with in one-year experiments. This paper gives an outline of these problems and indicates the ways in which they can be solved. The treatment is not exhaustive or formalistic since the subject has not yet reached a stage of development when any comprehensive treatment is possible.

41. YATES, F., and BOYD, D. A. 1948. *The relative yields of different crops in terms of food and their responses to fertilizers*. Agric. Prog. (In the press).

This paper was given before the Agricultural Education Association with the object of considering the problems involved in the expansion of agricultural production in this country, particularly those arising in the determination of the correct balance between the different agricultural crops, and the most effective utilisation of fertilizers.

The relative efficiency of different types of farm animal in acting as converters of feeding stuffs into human food is discussed, and a balance sheet of the production of animal feeding stuffs and the consumption based on the requirements of the known animal population is made and related to the amount of food produced for direct human consumption.

It is shown that the biggest possibilities of expansion and production lie in increasing the yield of grassland, and it is pointed out that experimental results show that very substantial increases in yield can be obtained by the greater use of nitrogenous fertilizer. The results of the Survey of Fertilizer Practice show that this practice is already spreading in certain areas. The utilisation of such increased yields of grassland will of course demand greater concentration on dried grass and silage and a corresponding increase in the animal population, particularly if the present area of grassland is retained.

42. YATES, F. 1948. *Operational research*. Nature, **161**, 609.

REPORTS

43. BOYD, D. A., and LORD, ROWENA. 1948. *Survey of fertilizer practice*. Results of the rapid survey scheme.
44. YATES, F. 1948. *Survey of maincrop potatoes: preliminary results of sampling for yield*.
45. BOYD, D. A. 1948. *Results of a grass-cutting experiment at Medbourne, Leics*.
46. BOYD, D. A. 1948. *Report on the results of grass-cutting experiments, 1945-47*.
47. BOYD, D. A. 1948. *National Agricultural Advisory Service Conference of Advisory Chemists. Soil sampling sub-committee: soil sampling investigation—interim report*.
48. BOYD, D. A. et al. *Survey of Fertilizer Practice reports: Anglesey, Caernarvon, Devon, Durham, Lancashire, Northumberland, Westmorland*.
49. YATES, F., and BOYD, D. A. 1948. *The utilization of limited additional supplies of nitrogenous fertilizer*.

Plant Pathology Department

BOOK

50. BAWDEN, F. C. 1949. *Plant Viruses and Virus Diseases*. Chronica Botanica, Waltham, U.S.A.

GENERAL PAPERS

51. BAWDEN, F. C. 1948. *Host-plant physiology and resistance to viruses*. Proc. Roy. Soc. B., **135**, 171.
52. BAWDEN, F. C. 1948. *Variations in Plant Viruses*. Proc. Colloque International, Unités Birlogiques douées de Continuité Génétique.
53. GLYNNE, M. D. 1948. *Fungus Diseases of Wheat*. Farming, **2**, 210.
54. HULL, R. 1949. *Sugar Beet Diseases*. Ministry of Agriculture Bulletin, No. 142.

RESEARCH PAPERS

55. BAWDEN, F. C., and ROBERTS, F. M. 1948. *Photosynthesis and predisposition of plants to infection with certain viruses*. Ann. Appl. Biol., **35**, 418.

The effects on susceptibility to infection with certain viruses of subjecting plants to various periods of darkness or reduced illumination before and after inoculation were tested. The viruses and hosts used were a tobacco necrosis virus in French bean and tobacco; tomato aucuba mosaic virus in tobacco; and tobacco mosaic and tomato bushy stunt viruses in *Nicotiana glutinosa*. All the virus-host combinations give necrotic local lesions, and susceptibility was measured by local lesion counts. Susceptibility was consistently increased by pre-inoculation treatments of host plants, whereas post-inoculation treatments had relatively little effect, but most often decreased susceptibility.

Short periods in the dark produced similar responses to longer periods in shade, but the different plants varied in their response to, and tolerance of, darkness. The maximum number of lesions was usually obtained with bean plants kept for 24 hr. in the dark before inoculation, but with tobacco plants susceptibility increased with increasing time in the dark up to 5 days.

It is suggested that the successful establishment of infection occurs in two stages, the first of which is affected by the accumulation of photo-synthetic products. Whether these products confer resistance by increasing cell turgor or by reacting specifically with virus particles is unknown, but sap from plants in the light possesses no greater virus-inhibiting power than sap from plants kept in the dark.

56. BROADBENT, L. 1948. *Aphis migration and the efficiency of the trapping method*. Ann. Appl. Biol., **35**, 379.

Reproducible results were obtained when adhesive traps for aphids were placed at the same height in different parts of a potato field. The total catches in different localities in different seasons can therefore justifiably be compared. During the summer dispersal flights, different species flew at different heights, so traps at one height only are not suitable for comparing the relative abundance of different species. There was less variation in numbers caught on traps at 3-4 ft. above the ground than on traps at 5-6 ft. or at ground level.

During the first fortnight of July an average of 200 aphids, 1.6 per cent. of which were *Myzus persicae*, was caught on traps in the position of potato plants. Most of these were not potato aphids, but it is suggested that some of them might act as vectors of potato viruses. The number of aphids caught was roughly proportional to the volume of free air space around the traps, and as the foliage increased in density the numbers caught on lower traps decreased in proportion.

Wind-speed records within and above the crop are discussed and it is shown that conditions are often suitable for voluntary aphis flight in and near the crop on relatively windy days. Records of catches on the half-traps facing the wind and on the other halves showed that voluntary flight decreased with increasing height.

Brilliant yellow traps, coated with adhesive grease, caught more aphids than white traps, which in turn caught more than black.

57. BROADBENT, L. 1948. *Methods of recording aphid populations for use in research on potato virus diseases*. Ann. Appl. Biol., **35**, 551.

Methods of counting aphids infesting potato crops are reviewed and discussed. The results of an aphid survey in different parts of England

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during 1946 and of counts at Rothamsted during 1947 are given and used to illustrate methods of expressing the counts; the extent of virus spread in 1946 showed no close correlation with aphid numbers. It is concluded that an estimate of the number of aphids per plant is better for virus disease research than the number per 100 leaves. A method of estimating the number of aphids per plant with tolerable accuracy is described, but it is concluded that for most surveys a method which does not necessitate the counting of the aphids is adequate. Such a method, based on the percentage of leaves infested, is described.

58. BROADBENT, L. 1949. *Factors affecting the activity of alatae of the aphids Myzus persicae (Sulzer) and Brevicoryne brassicae (L.)*. Ann. Appl. Biol., **36**, 40.

Apparatus was designed for testing the frequency of flights of aphids under different conditions of temperature, relative humidity, light and pressure. Young aphids (1-4 days after metamorphosis) flew more often and showed less individual variability than older ones; with all ages activity increased for the first few hours under experimental conditions. Starving increased activity for the first 1-2 hours. Aphids used on a second time flew less frequently than controls which had remained on the plant the first day. Alate *B. brassicae* were more active than *M. persicae*; both species showed alternating periods of activity and quiescence.

At light intensities between 100 and 1000 foot candles there was little difference in flight frequency, but below 100 foot candles activity declined rapidly and apparently ceased with darkness.

Changes in relative humidity temporarily affected flight frequency, a change to a higher humidity retarding, a change to a low increasing it. After adjusting to the change aphids flew readily at all humidities tested between 50 and 100 per cent. with temperatures below 80°F. (26.7°C.). The combination of high humidity and high temperature (90°F. = 32.2°C.) sometimes inhibited flight.

Changes of pressure often increased activity temporarily and flight frequency was greater under fluctuating pressure than under constant pressure.

It is concluded that changes in microclimate in crops are adequate to influence frequency of flight of aphids and consequently the spread of virus disease.

59. BROADBENT, L., and DONCASTER, J. P. 1949. *Alate aphids trapped in the British Isles, 1942-47*. Ent. Mon. Mag. (In press).

Adhesive aphid traps were operated at 40 places in Britain during six years. Total catches in the different areas are compared and a list of species caught is given. The catches of a number of species are discussed in detail. Peak catches of one species or another occurred in each month from May to September. Different species had different cycles of abundance and scarcity. *Myzus persicae* (Sulz.) and *Acyrtosiphon onobrychis* (Fonsc.) were the only species recorded at all centres.

60. BROADBENT, L., DONCASTER, J. P., HULL, R., and WATSON, M. A. 1948. *Equipment used for trapping and identifying alate aphids*. Proc. R. ent. Soc. Lond. (A), **23**, 57.

A detachable type of adhesive trap is described, the cover of which can be changed in the field in a few moments and sent to the laboratory for the collection of the aphids. Some additional equipment for removing the grease simply and rapidly is also described.

61. BROADBENT, L., and GREGORY, P. H. 1948. *Experiments on the spread of rugose mosaic and leaf roll in potato crops in 1946*. Ann. Appl. Biol., **35**, 395.

A series of experiments on the spread of potato rugose mosaic (virus Y), and leaf roll, which has been in progress on a uniform plan since 1943, was ended in 1946. Mean values for thirteen centres in England and Wales showed that in 1946 69 per cent. of the infections with virus Y and 48 per cent. of those with leaf roll virus reached the tubers of Majestic potatoes by the beginning of August. There was usually little subsequent increase of rugose mosaic, but a late increase of leaf roll was associated with a relatively high initial spread. Three-quarters of the virus Y and over half the leaf roll infections occurred within five plants distance of the source. There was no close correlation between the spread of either virus and the maximum number of *Myzus persicae*, either apterous forms on the plants or alate forms caught on adhesive traps, but centres with high trap catches in July and August

showed pronounced late season spread of leaf roll. There were marked differences at different centres in the relative spread of the two viruses. The amount of spread and the gradients from source of infection of the two viruses are compared over the period of 1943—6.

62. GARRETT, S. D. 1949. *A study of violet root rot. II. Effect of substratum on survival of Helicobasidium purpureum colonies in the soil.* Trans. Brit. Mycol. Soc. (In press).

Plates of different nutrient agars were inoculated with *Helicobasidium purpureum* and incubated for two months at 25°C.; the fungus colonies were buried in jars of soil for three to four months, and then tested for viability by inoculation of carrot seedlings. Survival was increased by raising the carbohydrate concentration of the medium, but depressed by excess of nitrogen. The optimum nitrogen requirement for survival increased with rise in carbohydrate content. Survival was correlated with the production of firm resilient sclerotia around the centre of the colony. The depressing effect of excess nitrogen upon production of sclerotia and survival of colonies is attributed to an increased density of mycelial growth, leading to reduction of carbohydrate level below that required for maturation of viable sclerotia.

63. GARRETT, S. D., and MANN, H. H. 1948. *Soil conditions and the take-all disease of wheat. X. Control of the disease under continuous cultivation of a spring-sown cereal.* Ann. Appl. Biol., 35, 435.

In a field experiment on the control of take-all at the Woburn Experimental Station, winter wheat was followed by two consecutive crops of spring-sown barley. Samples of the barley crop were taken from the forty-eight plots of the experiment in 1945 and 1946, for estimation of root Disease Rating, and grain yields were also recorded. A comparison of six autumn treatments of the stubble has shown that treatments affecting the available nitrogen content of the soil exercised a predominant effect upon incidence of take-all in the following crop. Two effects of nitrogen applied in autumn have been distinguished: (1) an immediate effect, in assisting survival of *Ophiobolus graminis* in infected root and stubble residues; (2) a deferred effect, in promoting disease escape of the following crop. The ploughing in of straw in autumn was found to increase the incidence of take-all, presumably because the adverse deferred effect of decomposing straw in locking up available nitrogen and withholding it from the following crop outweighed its beneficial immediate effect in helping to starve out *O. graminis*, by depriving the fungus of nitrogen. The autumn growth of undersown trefoil (*Medicago lupulina*) on the stubble land seemed to be entirely beneficial; active growth of the legume appeared to assist in starving out *O. graminis*, and nitrogen was released by decomposition of the trefoil in the soil after spring ploughing in time to benefit the barley crop immediately following.

64. GREGORY, P. H. 1948. *The effect of roguing on the spread of virus diseases in potatoes at Rothamsted in 1946.* Ann. Appl. Biol., 35, 406.

Experiments on roguing virus-diseased plants from plots of Majestic potatoes, which have been in progress since 1943, were continued in 1946. Plots were rogued in mid-June, early and late July, and plants were lifted from these plots at the end of July, August and September respectively. Roguing had little effect in reducing the spread of rugose mosaic (caused by potato virus Y). The spread of leaf roll was reduced to half that on unrogued plots by roguing on 14 June. Later roguing did not reduce the spread of leaf roll, unless combined with early lifting. Early lifting increased the effect of early roguing. In spite of these results roguing main crop potatoes in the south of England is not considered a practical control measure.

65. GREGORY, P. H. 1948. *The multiple-infection transformation.* Ann. Appl. Biol., 35, 412.

Attention is drawn to the possibility of misinterpreting results which may arise when the incidence of an organism, or any other event, is expressed as percentage presence or absence on plots of standard area. Disease gradients when expressed as percentage are shown to be artificially flattened. The amount of flattening depends on incidence of the disease and the size of plot chosen. A table is given by which the necessary transformation can be made when the organism or event is distributed at random. Examples are given of leaf diseases: (1) distributed at random (*Phytophthora infestans*); and (2) aggregated (*Gymnosporangium juniperi-virginianae* and *G. clavariaeforme*). Methods of detecting and measuring aggregation are briefly discussed.

66. GREGORY, P. H. 1949. *Leaf diseases of Anemone coronaria in Cornwall*. Trans. Brit. mycol. Soc. (In press).

A description of the following leaf diseases affecting anemones grown for the flower crop in Cornwall is given from studies made in 1935-40: "winter browning", rust (*Puccinia pruni-spinosae*), powdery mildew (*Oidium sp.*) downy mildews (*Plasmopara pygmaea* and *Peronospora ficariae*) and black leaf spot (*Septoria anemones var. coronariae*).

67. KASSANIS, B. 1949. *A necrotic disease of forced tulips caused by tobacco necrosis viruses*. Ann. Appl. Biol., **36**, 14.

Tobacco necrosis viruses were found to be the cause of a severe necrotic disease which occurred in forced tulips in three different nurseries. From 20 to 50 per cent of some varieties, e.g. Alberio, Korneforus, Crater, Rose Copland and Krelage's Triumph were affected, whereas others growing under the same conditions remained apparently healthy. The characteristic symptoms of the disease are necrotic spots and streaks, which cause much stunting and twisting and soon kill small plants. The disease was reproduced by inoculating healthy tulips with tobacco necrosis viruses.

68. KASSANIS, B. 1949. *The transmission of sugar beet yellows virus by mechanical inoculation*. Ann. Appl. Biol., **36**, 270.

Sugar beet yellows virus, hitherto transmitted only by aphides, can be transmitted mechanically to sugar beet if a suitable abrasive is used. Most inoculated leaves develop local lesions, but systemic infection usually occurs in only 10 per cent of the inoculated plants. Systemic symptoms develop more slowly than in plants infected with aphids.

69. KLECKZKOWSKI, A. 1949. *The transformation of local lesion counts for statistical analysis*. Ann. Appl. Biol., **36**, 139.

An analysis of the frequency distribution of local lesions, produced by viruses on half-leaves of a number of plants, shows that their standard error increases with increasing mean. Hence analysis of variance and statistical test of significance should not be applied to lesion numbers unless they are suitably transformed. The transformation into logarithms over-corrects so that the standard error decreases with increasing mean. A satisfactory transformation is $y = \log_{10}(x+c)$, where x is the number of lesions and c is a constant. A method is given of assessing c for different experiments. Great accuracy is not needed; in an experiment discussed in detail a satisfactory transformation is obtained with any value for c between 15 and 80.

On individual plants the numbers of lesions formed on half-leaves are distributed more or less normally, whereas their distribution about the common mean for many plants is skew and "leptokurtic". The distribution of the transformed numbers is almost normal, both for individual plants and about the common mean for a number of plants; it is only slightly skew.

70. KLECKZKOWSKI, A. 1949. *A quantitative study of complex formation in heated protein mixtures*. Biochem. J., **44**, 573.

The ratios of constituent proteins in complexes formed by human serum albumin with tobacco mosaic virus and with tomato bushy stunt virus during heat denaturation in solutions containing M/15 phosphate buffer at pH 6.8, were studied. When heated alone both viruses coagulate, whereas the albumin does not, although it aggregates increasingly with increasing concentration. When the albumin/virus ratio in the complex is 1.8 or higher, the complex forms a stable solution. All the virus and only a proportion of the albumin participate in the formation of such a complex.

Heat denatured tobacco mosaic virus, combined with albumin, has no nucleic acid and no serological activity, whereas bushy stunt virus retains both. When the albumin/bushy stunt virus ratio in the complex is over 3, the complex is not precipitable by virus antibodies, though it combines with them.

At a constant virus concentration the albumin/virus ratios in the complex increase with increasing concentration of albumin; the ratios decrease with increasing virus concentration when the albumin concentration is constant; the ratios increase with increasing total protein concentration when the proportion of the constituents remains constant, and with increasing temperature when all other conditions are constant.

In similar conditions about 2.4 times more albumin combines into a complex with heat denatured tobacco mosaic virus than with bushy stunt virus.

The ratios of the components in individual aggregates of the complexes probably vary, so that the estimated ratios are averages.

Heat-denatured albumin molecules aggregate more rapidly with particles of heat-denatured viruses than with one another.

71. SHEFFIELD, F. M. L. 1946. *Preliminary studies in the electron microscope of some plant virus inclusion bodies*. J. Roy. Microscopical Soc., **66**, 69.

Using micro-dissection methods, various parts of the contents of healthy and virus infected cells were isolated and prepared for examination in the electron microscope. Mixed cytoplasm and sap from healthy cells consisted chiefly of small particles in size from 20 μ to below the limits of resolution of the electron microscope. In the amorphous and crystalline inclusions due to strains of tobacco mosaic virus, rods of about 15 μ width and various lengths were found. Virus in smaller quantities was also found in mixed cytoplasm and sap from infected cells. In the amorphous inclusions due to severe etch virus, many crystals of various shapes too small to be seen in the light microscope were found. There is some evidence to support the suggestion that the particles of this virus are rod-shaped.

Biochemistry Department

72. HOLDEN, M., and CROOK, E. M. 1948. *Some factors affecting the extraction of nitrogenous materials from leaves of various species*. Biochem. J., **43**, 181-185.
73. HOLDEN, M., and TRACEY, M. V. 1948. *The effect of fertilizers on the levels of nitrogen, phosphorus, protease and pectase in healthy tobacco leaves*. Biochem. J., **43**, 147-151.
74. HOLDEN, M., and TRACEY, M. V. 1948. *The effect of infection with tobacco-mosaic virus on the levels of nitrogen, phosphorus, protease and pectase in tobacco leaves and on their response to fertilizers*. Biochem. J., **43**, 151-156.
75. LEES, H. 1948. *Trace elements and nitrification*. Nature, **161**, 398.
76. LEES, H. 1948. *The effects of various organic materials on soil nitrification*. Biochem. J., **42**, 528-531.
77. LEES, H. 1948. *The immobilization of mineral nitrogen in soils by different organic materials*. Biochem. J., **42**, 531-534.
78. LEES, H. 1948. *The effects of zinc and copper on soil nitrification*. Biochem. J., **42**, 534-538.
79. PIRIE, N. W. 1948. *The nature and development of life and our ideas about it*. Modern Quarterly, **3**, 82-93.
80. PIRIE, N. W. 1948. *Noted on the simultaneous publication of papers at two different levels of completeness*. Roy. Soc. Sc. Inf. Conf., Paper 21.
81. PIRIE, N. W. 1948. *The development of our ideas on the nature of viruses*. Brit. med. Bull., **5**, 329-333.
82. PIRIE, N. W., and PATERSON, J. S. 1948. *Attempted active immunization of cattle against Br. abortus infection with an antigenic fraction*. J. Comp. Path & Therapeutics, **58**, 227-231.
83. PINCUS, G., PIRIE, N. W., and CHANG, M. C. 1948. *The effects of hyaluronidase inhibitors on fertilization in the rabbit*. Arch. Biochem., **19**, 388-396.
84. TRACEY, M. V. 1948. *A possible role of D-amino-acids*. Biochem. Soc. Symposia, **1**, 89.
85. TRACEY, M. V. 1948. *Leaf protease of tobacco and other plants*. Biochem. J., **42**, 281-287.
86. TRACEY, M. V. 1948. *Proteins and life*. Pilot Press Ltd.
87. TRACEY, M. V. 1948. *Human biochemical genetics*. Brit. med. Bull., **5**, 325-329.
88. TRACEY, M. V. 1948. *A manometric method for the estimation of milligram quantities of uronic acids*. Biochem. J., **43**, 185-189.
89. TRACEY, M. V. 1948. *The determination of uronic acids in soil*. Analyst, **73**, 554-555.

Nematology Department

90. GOODEY, J. B. 1948. *The galls caused by Anguillulina balsamophila (Thorne) Goodey on the leaves of Wyethia amplexicaulis Nutt and Balsamorhiza sagittata Nutt*. J. Helminth., **22** (2), 109-116.
- J. Basil Goodey gives a detailed account of the structure of the galls on the leaves of *Wyethia amplexicaulis* and *Balsamorhiza sagittata*. The galls

have an innermost zone of cells with dense contents which is surrounded by a zone of vascular tissue and bounded externally by assimilatory tissue. It is suggested that the galls are caused by excretions similar to growth promoting substances. There are two text figures.

91. GOODEY, T. 1948. *Plant parasitic nematodes: a brief survey and some present day trends*. Lecture delivered before Section VIII, Applied Zoology and Parasitology, 13th International Congress of Zoology, Paris, July, 1948.

A short sketch of the history of the study of plant parasitic nematodes was followed by some account of infestations giving rise to flower galls in wheat, *Ang. tritici*, and in grasses, *Ang. agrostis*, with an indication of the commercial losses caused by the latter. In dealing with the stem eelworm, *Ang. dipsaci*, particular attention was given to its means of dispersal in the quiescent stage on seeds, e.g. teasel and onion. The importance of weeds as reservoir hosts was also stressed. In dealing with biological aspects of infestations due to species of *Heterodera* the significance of root diffusates was emphasized and attention was directed to the formation of giant cells in roots invaded by *H. marioni*; their function as special sources of food for the growing and adult parasite was brought out. A brief account of some of the problems connected with infestations caused by species of *Aphelenchoides* was also given.

92. GOODEY, T. 1948. *A note on the presence of phasmids on the male tails of Anguillulina multicincta, A. erythrinae and A. robusta*. J. Helminth., 22, (3/4), 139-140.

This short paper describes and figures the phasmids, lateral sensory papilla-like organs, on the male tails of three species of the genus *Anguillulina* in which they had not previously been found though they had been found on the tails of females of the same species.

93. PETERS, B. G. 1948. *Final report by Dr. B. G. Peters, Department of Nematology, Rothamsted on trials with D-D against potato eelworm (Heterodera rostochiensis)*. (Report No. A.R.C. 9967. 18 pp. Confidential).

This is the last of three confidential reports to the Agricultural Research Council on the results of a field experiment, spread over seven sites, to test the nematocidal effects of injecting D-D into the soil, prior to planting potatoes, to kill the potato root eelworm. Publication of the details elsewhere has been sanctioned, so it may be said that, although it was possible to kill some 40 per cent. of eelworms by this means, there were rather more eelworms on treated than on control plots after growing a potato crop.

94. PETERS, B. G. 1948. *Potato root eelworm, D-D and soil sterilization. I. Methods and criteria*. J. Helminth., 22, 117-127.

Methods are described whereby a factorial experiment was set up to test the effects, on 40 potato plants (each growing in a 15 kg. pot of soil), of the three following factors: (S) steam sterilization of soil, (H) infection of soil with about 3 million eggs and larvæ of *Heterodera rostochiensis* per pot, and (D) injection of soil with 10 ml. of D-D mixture per pot, the factors applied in that order.

From a statistical analysis of the data from 10 plant criteria, two were selected as, between them, covering all the significant treatment effects; these criteria were (a) height of tallest shoot at 45 days after planting, and (b) weight of all tubers produced.

Eelworm counts from the 20 infected pots were also used to measure the effects of (S) and (D) on the eelworm population; these counts were analysed in logarithmic transformation.

95. PETERS, B. G. 1948. *Potato root eelworm, D-D, and soil sterilization. II. Results for 1946*. J. Helminth., 22, 128-138.

Using the methods of the previous paper, it was found that D-D mixture at the dose used was lethal to most of the eelworms, thus complicating the analysis. It could not be shown that eelworm infection had any effect on the plants. Soil sterilization had the expected positive effects. The overall D-D effects, also positive, are suspect for the reason given but the unexceptionable results in the absence of infection showed a positive effect on weight of tubers amounting to 28 per cent. of the steam-sterilization effect; this is the so-called "soil amendment" effect. A negative SD interaction revealed antagonism between these two factors.

Eelworm population was reduced by nearly 99 per cent. and slightly reflected the positive S and negative SD effects. The experiment was repeated in 1947.

96. PETERS, B. G. 1949. *The potato root eelworm problem*. Agriculture, 55, 493-498.

A review of the present position.

Entomology Department

BOOKS

97. BARNES, H. F. 1948. *Gall Midges of Economic Importance*. Vol. 3. Crosby Lockwood.

This is the third volume of the series which promises to become the standard work on the subject, and deals with the gall midges of 46 temperate and tropical fruits. Nearly 170 species of gall midges are dealt with in the text. Attention is focussed in the preface on two matters of general interest—the species problem and the need for phenological observations to aid correct timing in control measures.

The first volume dealt with the global gall midges of root and vegetable crops, while the second treated the gall midges of fodder crops in a similar manner.

98. BARNES, H. F. *Gall Midges of Economic Importance*. Vol. 4, Crosby Lockwood.

This fourth volume deals with the gall midges of 44 ornamental plants and shrubs. Reference is made in the preface to the reason for subdividing this work on gall midges of economic importance into eight volumes, to the incidence of species of the genus *Clinodiylosis* and to the pernicious habit of naming midges on the larvæ and gall and even on the gall alone.

PAPERS

99. WILLIAMS, C. B. 1948. *Butterfly Migration*. A Daily Mail School Aid Publication.
100. WILLIAMS, C. B. 1948. *The Rothamsted light trap*. Proc. R. Ent. Soc., A.23, 80-85.

An account of the design and construction of the light trap which has now been in use at Rothamsted for over 7 years. Photographs and scale drawings are included so that similar traps can be constructed.

101. WILLIAMS, C. B. 1948. *Some Problems of animal migration*. The New Naturalist, 1, 133-141.

A popular account of the migration of birds, fishes and insects and some of the problems and difficulties of study.

102. WILLIAMS, C. B. 1948. *Notes on British Immigrant Butterflies*. The New Naturalist, 1, 141-144.

Bee Department

103. BUTLER, C. G. 1948. *Aspects of Bee Behaviour*. Discovery, 9, 107-110.

A short, popular, account of some recent research on the foraging behaviour of honeybees and of the methods of communication practised by them.

104. BUTLER, C. G. 1948. *The Importance of Bees in Orchards*. Ministry of Agriculture and Fisheries, Advisory Leaflet, No. 328.

Gives advice on the employment of stocks of honeybees for pollination of fruit trees in orchards; the determination of the number of stocks, if any, required in any particular orchard; the arrangement of the stocks in the orchard and protection of the bees against poisonous sprays and dusts.

105. BUTLER, C. G. 1948. *Bee Research*. Scottish Agriculture, 27, 131-135.

An account of the development of the technique of artificial insemination of queen honeybees and of the part which this new technique is likely to play in the development of strains of bees for the pollination of the flowers of specific seed crops. The control of American Foul Brood by the development of strains of bees that exhibit resistance to the disease, and by the use of sulphonamides, etc., is also discussed.

106. BUTLER, C. G. 1948. *Bee Behaviour*. Proc. Royal Institution. (In press).
A discourse on recent work on the division of labour in the honeybee colony and of the behaviour of honeybees in the field whilst seeking nectar and pollen.
107. BUTLER, C. G. 1949. *Bee Behaviour*. Nature, **163**. (In press).
A somewhat condensed account of the discourse mentioned above.
108. BUTLER, C. G. 1949. *An introduction to the Sense Physiology and Behaviour of the Honeybee*. Book. Oxford Univ. Press. (In press).
109. BUTLER, C. G. 1949. *Bee-Hives*. Ministry of Agriculture and Fisheries Bull. (In press).
A discussion of the development of the modern hive and of the principles underlying its construction; also of the advantages and disadvantages possessed by a number of single and double-walled hives, of both British and American origin in use in Britain today.
110. MILNE, P. S. 1948. *Treatment of Acarine disease with sulphur fumes*. Scottish Beekeeper, **24**, 205-206.
Notes on practical experience gained from the treatment of a number of Acarine-infested colonies of bees with the fumes of burning corrugated brown paper impregnated with potassium nitrate and sulphur. The method of preparing the sulphur cartridges is described.
111. RIBBANDS, C. R. 1948. *The foraging behaviour of Honeybees*. Agriculture, **55**, 252-255.
A popular account of von Frisch's recent experiments, and their possible application to farming.
112. RIBBANDS, C. R. 1949. *Some foraging methods of individual Honeybees*. J. Anim. Ecol., **18**. (In press).
The movements of individually marked foragers were recorded from day to day, and a few selected bees were watched continuously for periods of a day or more. The following conclusions have been drawn:—
(a) The basic principle underlying the foraging behaviour pattern is the exhibition of trial and error learning of considerably complexity. The honeybee continuously chooses the best of any alternative crops with which she becomes acquainted, and compares present crops with her memory of past crops.
(b) A bee usually attaches herself to a particular area of the most profitable crop found. The size of this foraging area varies considerably.
(c) Honeybees may use choice and memory in order to select the most suitable blossoms of the crop they are working, in order gradually to change the position of the foraging area, when working two crops at once or when working one crop and inspecting another, when working two crops at different times of the day, when crops are failing, and when changing crops. Some foragers exhibit a centripetal tendency which is considered to be a consequence of the interplay between choice and memory.
(d) Attachment to a particular crop may be of any duration, from a few visits to a lifetime. The proportion of changes of attachment varies greatly with local circumstances, since behaviour is very liable and readily adaptable to changing conditions.
113. SIMPSON, J. *A Hornet's Nest*. Entomologists' Monthly Mag., **84**, 128-129.
A description of the structure, and composition of the population throughout its existence, of a hornets' nest.
114. WAY, M. J., and SYNGE, A. D. 1948. *The effects of D.D.T. and Benzene Hexachloride on bees*. Aun. appl. Biol., **35**, 94-109.
Although it was demonstrated in the laboratory that D.D.T. in fairly high concentrations acts as a contact poison to bees and also as a stomach poison that is rather more toxic than lead arsenate, it was found that in the field the commercial preparations of D.D.T. that were tested by application to open blossom are apparently harmless to foraging bees.
Laboratory experiments showed that Benzene Hexachloride is a powerful contact and stomach poison to honeybees and bumble bees, and the results of field experiments with commercial preparations confirm its potential danger to foraging bees.

Insecticides and Fungicides Department

115. LORD, K. A. 1948. *The contact toxicity of a number of D.D.T. Analogues and of four isomers of benzene hexachloride to Macrosiphoniella sanborni and Oryzaephilus surinamensis.* Ann. App. Biol., **35**, 505-526.

Twenty-three analogues of D.D.T. and four isomers of benzene hexachloride have been compared with D.D.T. for toxicity as contact insecticides using a direct spraying technique. Each substance has been tested against two insect species: *Macrosiphoniella sanborni* and *Oryzaephilus surinamensis*. The substances tested included a number of halogen and alkyloxy analogues of D.D.T. and a number of compounds of varying degrees of chlorination between diphenylethane and D.D.T.

The biological data have been examined, as far as possible, by the method of probits.

The probit lines for the D.D.T. analogues varied both in position and in slope: those for the isomers of benzene hexachloride in position but not in slope. In general, neither the relative positions nor the relative slopes of the probit lines for the various substances were the same against the two insect species.

The toxicity of substances analogous to D.D.T. appears to be related to molecular weight, with maximum toxicity occurring in the molecular weight range 300-450.

Among D.D.T. analogues the slope of the probit line is apparently correlated with molecular volume. The variation of the slope of the probit lines has been discussed, and it has been concluded that it arises from differences in the interaction of the poisons with the test-subjects.

The various theories relating to the toxicity of D.D.T. and B.H.C. have been discussed in relation to the experimental data described here. To account for all the experimental results by means of one theory it is necessary to postulate a physico-chemical mechanism of toxic action. Such a mechanism implies that the intensity of biological action will be dependent upon the physico-chemical properties of the poisons, whether or not a specific molecular configuration is involved, and toxicity is therefore dependent on the molecule as a whole.

116. LORD, K. A. 1948. *The sorption of D.D.T. and its analogues by chitin.* Biochem. J., **43**, 72-78.

D.D.T. and its analogues are readily sorbed by chitin from colloidal suspensions. The sorptive power appears to be peculiar to chitin since cellulose, wool, and silica powder do not possess this power.

The rate of sorption is dependent upon the concentration of the colloidal suspension, and the amount sorbed appears to be dependent upon the surface area of the chitin.

The molecular amounts of D.D.T. and its analogues appear to be approximately equal as are the rates of sorption.

117. LORD, K. A. 1948. *Decomposition of D.D.T. (1:1:1-trichloro-2:2-di-(4-chlorophenyl)-ethane) by basic substances.* J. Chem. Soc. 1657-1661.

The reaction between D.D.T. and some basic substances has been investigated at 30°C. It has been shown that the rate of decomposition of D.D.T. by methylamine is dependent upon the square of the amine concentration.

118. STOKER, R. I. 1948. *The phytotoxicity of D.D.T. and of benzene hexachloride.* Ann. Appl. Biol., **34**, No. 3.

Spraying with two preparations of D.D.T. had a negligible effect on the maturation of outdoor tomatoes and of summer cabbage. Spraying with a commercial D.D.T. suspension damaged cucurbits and treatment with the suspension base distorted glasshouse cucumbers during one season only.

Benzene hexachloride (B.H.C.) sprays did not effect the yield or flavour of tomatoes, but, at concentrations higher than those normally used, they severely scorched radish, turnip, swede, kale, spinach and beetroot seedlings. The application of B.H.C. dusts stunted seedlings of radish.

On one occasion young potato foliage was damaged by relatively high concentrations of two compounded B.H.C. sprays and by B.H.C. dust but late-season older foliage was unaffected. A spray compounded from B.H.C. dispersible powder caused tainting of potatoes, peas, carrots, beetroot, marrows, cauliflowers and lettuce. Apples and plums treated with B.H.C. spray preparations developed a taint after cooking.

119. WAY, M. J., and SYNGE, A. D. 1948. *The effects of D.D.T. and of benzene hexachloride on bees*. Ann. Appl. Biol., **35**, No. 1.

Laboratory and field experiments were carried out during 1946 to determine the effects of D.D.T. and of benzene hexachloride (B.H.C.) on honey-bees and on several wild bee species.

Laboratory experiments show that B.H.C. is a powerful contact and stomach poison and results of field experiments with commercial preparations confirm its danger to the foraging bee population. A few minutes' contact with treated surfaces is sufficient to cause death and blossom may remain poisonous for at least 3 days after treatment.

In the laboratory D.D.T. has a contact action at fairly high concentrations and as stomach poison is rather more toxic than lead arsenate. In the field, commercial preparations on open blossom are apparently harmless to foraging bees.

Woburn Experimental Station

120. MANN, H. H., and BARNES, T. W. 1947. *The competition between barley and certain weeds under controlled conditions. II. Competition with Holcus mollis*. Ann. Appl. Biol., **34**, 252-266.
121. GARRETT, S. D., and MANN, H. H. 1948. *Soil conditions and the take-all disease of wheat. X. Control of the disease under continuous cultivation of a spring-sown cereal*. Ann. Appl. Biol., **35**, 435-442.
122. MANN, H. H., and BARNES, T. W. 1948. *The competition between barley and certain weeds under controlled conditions. 3. Competition with Agrostis gigantea*. Ann. Appl. Biol. (In press).