ROTHAMSTED RESEARCH

Rothamsted Report for 1947

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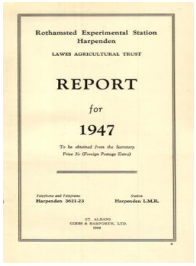

Departmental Publications / Abstracts of Papers

Rothamsted Research

Rothamsted Research (1948) *Departmental Publications / Abstracts of Papers ;* Rothamsted Report For 1947, pp 107 - 131 **- DOI: https://doi.org/10.23637/ERADOC-1-89**

PUBLICATIONS

Department of Physics

1. PENMAN, H. L. 1948. *Natural evaporation from open water, bare soil and grass.* Proc. Roy. Soc., **A., 193,** 120-145.

Two theoretical approaches to evaporation from saturated surfaces are outlined, the first being on an aerodynamic basis in which evaporation is regarded as due to turbulent transport of vapour by a process of eddy diffusion, and the second being on an energy basis in which evaporation is regarded as one of the ways of degrading incoming radiation. Neither approach is new, but a combination is suggested that eliminates the parameter measured with most difficulty—surface temperature—and provides for the first time an opportunity to make theoretical estimates of evaporation rates from standard meteorological data, estimates that can be retrospective.

Experimental work to test these theories shows that the aerodynamic approach is not adequate and an empirical expression, previously obtained in America, is a better description of evaporation from open water. The energy balance is found to be quite successful. Evaporation rates from wet bare soil and from turf with an adequate supply of water are obtained as fractions of that from open water, the fraction for turf showing a seasonal change attributed to the annual cycle of length of daylight. Finally, the experimental results are applied to data published elsewhere and it is shown that a satisfactory account can be given of open water evaporation at four widely spaced sites in America and Europe, the results for bare soil receive a reasonable check in India, and application of the results for turf shows good agreement with estimates of evaporation from catchment areas in the British Isles.

2. PENMAN, H. L. 1949. *The dependence of transpiration on weather and soil conditions.* J. Soil Sci., **1,** 74-89.

The evaporation from an open-water surface can be estimated from weather data; the ratio of the transpiration from plentifully watered turf to the evaporation from similarly exposed open water is known as a function of time of year. These results of earlier work are re-stated and used as a basis for estimating transpiration rates when optimum water supply is not maintained. It is assumed that the roots occupy a depth of soil which will yield a definite amount of water at maximum rate. After this amount is transpired the rate is limited by the ability of the lower soil to transmit water, and on the basis of earlier experimental work a composite drying curve is drawn up. With this curve and the relevant weather data it is possible to estimate the seasonal changes in the moisture content of soil under turf. It is shown that the times of the running of the field drains at Cambridge University Farm can be predicted using only one arbitrary constant—the available water in the root zone—which varies from year to year with the spring rainfall. No other collection of records is as satisfactory for testing purposes, but applications to drain gauge records from Craibstone (Aberdeen), Harrogate, Compton and Farlington have given generally satisfactory results. The survey shows the great desirability of wider studies of root development as affected by soil type and depth, fertiliser treatment and weather conditions.

3. SCHOFIELD, R. K., and PENMAN, H. L. 194 . *The concept of soil moisture deficit.* Proc. 2nd Int. Conf. on Soil Mechanics and Foundation Engineering, Rotterdam, June, 1948. (In the press.)

A study of the records of the Rothamsted drain gauges shows how soil moisture deficits develop in bare soil.

A measure of soil moisture deficits under grass and other crops can only be obtained by determining moisture percentages when the soil is very uniform and has the kind of structure that gives a rapid die-away of drainage. A way of reducing the disturbance caused by soil irregularity has been explored at Rothamsted.

Observations at Rothamsted show that evaporation from grass plentifully supplied with water is nearly the same as that from an equal area of open water and shows essentially the same dependence on weather.

An estimate of the mean annual evaporation from a grassed drain gauge, that is scarcely ever short of water, has been made from evaporimeter records. This agrees well with the observed annual excess of rainfall over drainage.

Assuming that evaporation from the grass of the Cambridge University Farm is checked when the soil moisture reaches a value, C (which varies

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slightly from one year to another), values for the soil moisture deficit have been estimated that correctly predict the time when drainage re-starts.

Typical values for C and for the maximum soil moisture deficits found at a number of sites in selected years have been tabulated.

It is not possible to determine uniquely the condition of zero soil moisture deficit in sandy soils with a deep water table.

4. SCHOFIELD, R. K. 1947. *Some problems connected with the retention of ions by clay constituents.* Clay Minerals Bull. No. 1, 16–18.

After repeated washing of a sample of a clay subsoil with N/5 ammonium chloride solution, adjusted by the addition of hydrochloric acid or ammonia to the required pH, the net negative charge was found by the excess of ammonium ions over chloride ions displaced by subsequent washing with potassium nitrate solution. At pH values between 2·5 and 5 a small retention of chloride ions which diminishes and ultimately vanishes with rise in pH shows that a small number of positive charges are present. A treatment with acid ammonium oxalate in sunlight dissolves some 5 per cent. of iron oxide and removes the positive charges. The residue contains the clay mineral with unimpaired base exchange power. This has a constant negative charge between pH 2·5 and pH 5 which is presumably due to isomorphous replacement. Above pH 5 the negative charge increases, no doubt due in the main to the dissociation of hydrions from hydroxyl groups attached to silicon.

5. SCHOFIELD, R. K. 1947. *Calculation of surface areas from measurements of negative adsorption.* Nature, **160,** 408.

A simple formula is given which relates the negative adsorption of ions per unit area of phase boundary carrying a large surface charge to the valencies and concentrations of the ions in solution. When the negative adsorption per unit weight of clay, or other sorbate, has been measured at a series of electrolyte concentrations the formula permits the calculation of the area of phase boundary. Applied to data for bentonite this method gave an area 450 square metres per gram. The theoretical maximum for pure montmorillonite is 800 square metres per gram.

A sample of jute carrying a high surface density of carboxyl groups was found to have an internal area of 160 square metres per gram, which is about one thousand times the external area of the fibres. There was an internal volume of 0·7 c.c. per gram, which evidently consists of passages of the order of 100 A in width. A sample of jute carrying a low surface density of carboxyl groups gave values almost equal to those that would be calculated from Donnan's equation for the membrane equilibrium.

6. SCHOFIELD, R. K. 194 . *A ratio law governing the equilibrium of cations in the soil solution.* Proc. Eleventh Int. Congress of Pure and App. Chem. (In the press.)

A ratio law applicable to the equilibrium between the exchangeable cations and those in solution has been verified over a limited range of concentration for potassium, magnesium, calcium, aluminium and hydrogen ions for soil samples from the Rothamsted Park Grass Plots. The law is not obeyed by hydrogen ions in the case of a soil from Natal which carries positive and negative charges in nearly equal amounts.

7. RUSSELL, E. W. 194 . *The determination of volume weight and air space of stony soils.* Proc. 2nd Int. Conf. on Soil Mechanics and Foundation Engineering, Rotterdam, June, 1948. (In the press.)

There are a number of reasonably good methods available for determining the volume weight and the volume of voids, or the air space, in stone-free soils if they are soft enough or moist enough to allow a sample of predetermined volume being taken with a suitably designed sampling tube or cylinder. These methods, however, fail, or become very inaccurate, for soils containing even quite small proportions of stones, for the sampling tube is bound to affect the packing of the soil inside the tube if the cutting edge meets a stone of appreciable size. For such soils it is preferable to take an undisturbed sample of soil, of irregular shape and unknown volume, and determine its volume after sampling. This can be easily done for very porous non-cohesive soils, such as gravels and coarse sands, by fixing the soil in a cement before removing the sample, as for example by pouring molten paraffin wax on to it and cutting out the block of impregnated soil.

There are usually no fundamental difficulties in taking an undisturbed sample of a cohesive soil, and the problem of determining its volume weight

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and volume of air form the subject of this paper. Volume weights can obviously be determined if the method developed involves displacing all the air by a liquid that is immiscible with water and then determining the volume of this impregnated sample by weighing it in the same liquid that has been used for impregnation. It is shown that this method is applicable to moist or dry soils, and that no elaborate apparatus is needed if only a volume weight is required, although a vacuum pump is essential if the volume of the air spaces is also required.

The principle of the method used is to weigh the sample in air, to impregnate it with a non-volatile water-insoluble oil of low viscosity, and weigh it in this oil, then to weigh the impregnated sample in air again when it is fully drained. From these weighings the volume of the sample and of the air space it contains can readily be calculated.

The points of technique discussed refer to the type of oil to be used, and it is shown that lamp paraffin (kerosene) can be made suitable; the method of replacing the air by this oil so that a minimum quantity of water from the moist sample is lost at the same time; and draining the excess liquid from the impregnated clod. If a moisture determination is made on the sample after these determinations have been made, the density of the soil particles themselves can be calculated, and this determination can often serve as a check on the accuracy of the whole procedure.

OTHER PAPERS

8. KEEN, B. A. 1947. *Middle East in transition.* Future, **2,** 37–46.
An article based on the author's report *"The agricultural development of the Middle East"*. (See paper No. 3 of the 1946 report.)

9. RUSSELL, E. W. 1946. *Modern ideas on potato cultivation.* Agric. Prog., **21,** 103–104.

10. PENMAN, H. L. 1947. *Future developments in agricultural meteorology.* Weather, **2,** 137–141.

11. SCHOFIELD, R. K., and RUSSELL, E. W. 1948. *The significance of particle size in relation to soils.* Conference on Particle Size Analysis organised by the Institution of Chemical Engineers, February, 1947.

12. RUSSELL, E. W. 1947. *Problems of soil and land classification.* Nature, **160,** 686–687.

Department of Chemistry

13. CROWTHER, E. M. 1947. *Fertiliser experiments in colonial agriculture.* Memoranda on Colonial Fertiliser Experiments, 10–28, H.M. Stationery Office, Colonial 214.

The Colonial Advisory Council of Agriculture, Animal Health and Forestry recommended that steps should be taken to carry out in Colonial territories fertiliser experiments with different crops on all soil types and through the sequence of cropping, with the object of obtaining precise information on the responses of crops to the different fertilisers, the economics of application, the use of any local fertiliser materials available and the role of trace elements. This memorandum sets out the general principles of experimental design and discusses their application to some of the more pressing problems in colonial agriculture. Special attention is given to factorial designs in which high-order interactions are confounded with blocks and to fractional replication. A convenient notation is given for working out the arrangement of blocks in such experiments. It is shown how complex experiments at a few centres can be supplemented by series of simple experiments, even of a purely observational nature, on large numbers of individual holdings. It is urged that the early trials in any area should be made with standard fertilisers and that local fertiliser material should be used in field trials only where they can be compared against standard fertilisers.

14. CROWTHER, E. M. 1948. *Fertilisers in the agricultural expansion programme.* Agriculture, **55,** 491-500.

The use of fertilisers in England and Wales in 1948 and the next few seasons is reviewed in relation to the vast agricultural expansion programme and the fertiliser supplies likely to become available. A provisional fertiliser programme is drawn up, and attention is directed to a number of ways in which the use of fertilisers must be improved if the wartime efficiency in crop production is to be surpassed or even maintained.

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15. CROWTHER, E. M. 1947. *The use of salt for sugar beet.* British Sugar Beet Review, **16,** 19–22.
A summary of the results of recent field experiments.
16. CROWTHER, E. M. 1947. *Soils and fertilisers.* J. Royal Agric. Soc., **108.**
17. HALE, J. B. 1947. *Mineral composition of leaflets in relation to the chlorosis and bronzing of oil palms in West Africa.* J. Agric. Sci., **37,** 236–244.
Some disorders causing chlorosis and necrosis of the foliage of oil palms from three West African estates have been investigated by spectrochemical analysis of the dry leaflets for potassium, calcium, magnesium and manganese.
Statistical examination of the chemical analyses of leaflets from fronds of different ages and from different positions along the frond, shows that it is important to sample and analyse separately at least upper, middle and lower fronds from each tree. Little is gained by analysing separately samples from different positions along the length of the frond.
The "bronzing" diseases are tentatively ascribed to deficiency of potassium. One palm is probably a case of combined magnesium and potassium deficiency. One disease, "lemon frond", cannot be attributed to a deficiency of any of the elements determined.
The differences in mineral composition of the leaflets between palms from the three estates are greater than those due to the diseases, and a further survey is proposed to determine the range of variation of composition of healthy trees and the levels below which deficiencies set in.
18. RICKSON, B. 1948. *A semi-micro combustion method for the determination of organic carbon.* Analyst, **73,** 268-274.

Department of Pedology

19. MACEWAN, D. M. C. 1946. *The investigation of soil clays by X-rays.* Chem. Indust., No. 36.
A brief account of present-day techniques.
20. MACEWAN, D. M. C. 1947. *The nomenclature of the halloysite minerals.* Min. Mag., **28,** 36–44.
A historical account of the name "halloysite" and an argument against the proposed new name "endellite". It is argued that the name "halloysite" was originally applied to the same material for which the new name is now proposed, i.e., the material with two extra molecules of water over the kaolinite formula, and that its application to the less hydrous form is a recent innovation. It is suggested that the name "halloysite" be used more generally to include both forms.
21. MACEWAN, D. M. C. 1948. *Les mineraux argileux de quelques sols ecossais.* Verre et Silicates Industriels.
An account of a mineralogical investigation by X-ray and chemical methods (the latter carried out by A. Muir) on the clays of three Scottish podzols derived from schists. Emphasis is laid on the importance of studying the clay mineralogy of the whole profile, as a means of tracing the processes of alteration.
The main points are: In the lowest horizons the minerals are essentially those of the parent rock (chlorites, biotite, muscovite), except that felspars are absent, and kaolinite is present (this constituent persists in about the same proportion throughout the profile). In the intermediate layer, biotite is replaced by hydrobiotitic material, and oxides of iron and aluminium appear (crystalline in one soil, amorphous or microcrystalline in the other two). Towards the surface chlorites and oxides disappear, biotitic material becomes less plentiful or disappears, and the main constituents are kaolinite and "illite"; the last-named may be found by hydration of the muscovite-like material.
22. GOLDSCHMIDT, V. M., and MUIR, A. 1947. *Geochemistry of minerals.* Thorpe's Dictionary of Applied Chemistry, Vol. 7.

Department of Soil Microbiology

23. ERICKSON, DAGNY. 1947. *Differentiation of the vegetative and sporogenous phases of the actinomycetes. 1. The lipid nature of the outer wall of the aerial mycelium.* Journal General Microbiology, Vol. 1, No. 1, 39–44.
The characteristic dry powdery appearance of the aerial mycelium of actinomycetes and the difficulty of wetting the constituent spores appear to be due to lipid substances in their outer walls. These substances are removed

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by fat solvents, and wetting agents, destroyed by alkali and are probably glyceride in nature. A staining with Sudan IV in ethanol clearly distinguishes the lipid-containing aerial mycelium from the vegetative mycelium.

24. ERICKSON, DAGNY. 1947. *Differentiation of the vegetative and sporogenous phases of the actinomycetes. 2. Factors affecting the development of the aerial mycelium.* Journal General Microbiology, Vol. 1, No. 1, 45–52.

When first isolated on soil extract agar, soil actinomycetes consistently produce aerial spores in surface colonies. They retain this property when maintained in sterile soil, or when grown on washed suspensions of common soil bacteria, living or dead, in a water agar medium. In soil, when the composition, moisture content and temperature are kept constant, the initial stimulus towards the production of aerial mycelium is free access of air; the quantity and nature, vegetative or sporogenous, of the inoculum, and, within a broad range, the pH of the soil are of minor importance. Once growth is established, the next most important factor stimulating sporulation in the soil is also physical, namely dehydration. In natural and sterilized soils of different origins, and in a "synthetic" soil containing 250 p.p.m. of nitrogen as nitrate, the modes of growth of different actinomycetes strains are similar, and generally uncharacteristic of their species.

25. HOLDSWORTH, M., and NUTMAN, P. S. 1947. *Flowering response in a strain of* Orobanche minor *L.* Nature, **160,** 223–224.

The relation between the flowering of the parasitic plant *Orobanche minor* L. and of its host red clover, was examined in experiments in which the sowing date was varied and parasitised plants were grown in different day lengths.

Early sown (January) or moderately late sown (June) Orobanche plants on clover sown in the early spring come into flower at about the same time (August). Delay in the sowing of the host plant (April to June) leads to a delay in the flowering of both host and parasite. Late sown (July onwards) clover and Orobanche both fail to come into flower in the seedling year.

The dependence of flowering in the parasite on the flowering of the host is further shown in their photoperiodic responses. Clover is a long day plant and its flowering can be inhibited by a day length of 11 hours; a treatment which results in a corresponding inhibition of flower formation in the parasite. Alternatively exposure to long day (16½ hours) leads to a simultaneous flowering of both host and parasite independently of sowing date. These results show that both host and parasite are long day plants although the latter being entirely subterranean cannot directly perceive length of day; some influence or substance affecting flower formation—possibly a common flowering hormone—must therefore be transmitted from the host to the parasite.

26. THORNTON, H. G. 1947. *The biological interactions of* Rhizobium *to its host legume.* Antonie van Leeuwenhoek, **12,** 85–96. Jubilee Volume, Albert J. Kluyver. (Review.)

27. OXFORD, A. E., and SINGH, B. N. 1946. *Factors contributing to the bacteriolytic effect of species of myxococci upon viable eubacteria.* Nature, London, **158,** 745.

A strain of *Myxococcus virescens* isolated at Rothamsted produces two substances. One is soluble non-enzymatic antibiotic substance, the other is an exocellular lytic (proteolytic) enzyme which is active against non-viable bacteria only.

28. SINGH, B. N. 1947 *Studies on soil acrasieae. 1. Distribution of species of* Dictyostelium *in soils of Great Britain and the effect of bacteria on their development.* Journal General Microbiology, **1,** No. 1, 11–21.

A method of isolating species of Dictyosteliaceae from soil and other substrates is described.

Of ninety-three different strains of bacteria tested as food for *Dictyostelium giganteum* and *D. mucoroides*, some were readily or slowly but completely eaten, others were partly eaten and the rest were inedible. No correlation between the edibility of the bacteria and the formation of normal fruiting bodies could be found. More Gram-negative than Gram-positive strains were edible, and non-pigmented bacteria proved more suitable than pigmented bacteria for the normal development of *Dictyostelium spp.*

Values of pH between 4·1 and 8·9 had no effect on the abundance or on the types of fruiting bodies produced in either *D. giganteum* or *D. mucoroides* when suitable strains of bacteria were supplied as food to the myxamoebae on non-nutrient sugar.

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The maximum dimensions and the form of sorocarps and occasionally the colour of the sori were influenced by the type of bacteria used as food supplies. The influence of the bacterial food supply on the classification of Acrasieae is discussed and one new species (*D. giganteum*) is described.

Species of *Dictyostelium* are frequently present in arable soils in Great Britain. The common occurrence of *Dictyostelium spp.* in soils, which have been unmanured or treated with artificial fertilisers only for 100 years or more, disproves the belief that *Dictyostelium spp.* are dung organisms.

29. SINGH, B. N. 1947. *Studies on soil acrasieae. 2. The active life of species of* Dictyostelium *in soil and the influence thereon of soil moisture and bacterial food.* Journal General Microbiology, **1**, No. 3, 361–367.

When spores of *Dictyostelium mucoroides* or *D. giganteum* were added to sterilized soil containing a pure culture of an edible bacterium, the resulting myxamoebae actively destroyed the bacteria in the soil. When spores of *D. mucoroides* were added to the centre of a Petri dish of sterilized soil containing bacterial food no fruiting bodies were formed at a moisture content of 15 per cent. or less. At 19 per cent. moisture fruiting bodies were formed at the centre only. At 33 per cent. moisture the central area over which fruiting bodies appeared steadily increased in size until it covered the whole soil surface. Species of *Dictyostelium* can also pass through the life cycle in fresh unsterilized soil.

The nature of the bacterial food supply affects the growth of species of *Dictyostelium* in soil as measured by fruiting body formation. Normal fructification occurs on soil containing certain bacterial strains which induce abnormal fructification on agar.

30. SINGH, B. N. 1947. *Myxobacteria in soils and composts; their distribution, number and lytic action on bacteria.* Journal General Microbiology, **1**, No. 1, 1–10.

Myxococcus virescens, M. fulvus, Chondrococcus exiguus and *Archangium sp.* are widely distributed in the soils of Great Britain including some treated only with artificial fertilisers. *Myxococcus virescens* and *Chondrococcus exiguus* appear to be the dominant species. The numbers of myxobacteria ranged from 2,000 to 76,400/g. of soil. In an actively decomposing compost of sludge and straw the number of *Myxococcus fulvus* was found to be over 500,000/g.; *M. virescens* and *Chondrococcus exiguus* were also present, but less abundantly.

Variation of pH between 4·0 and 8·8 does not affect the growth of *Myxococcus fulvus, M. virescens* and *Chondrococcus exiguus*, and normal fruiting bodies were produced in the presence of suitable bacteria. *Myxococcus fulvus* and *M. virescens* do not attack filter paper.

Both Gram-positive and Gram-negative bacteria growing on solid media may be lysed by extracellular secretions of *M. virescens, M. fulvus* and *Choncrococcus exiguus*. Of forty-seven Gram-positive and forty-seven Gram-negative strains of bacteria tested with three species of myxobacteria, a higher percentage of Gram-negative than of Gram-positive strains was attacked. Pigmented strains of bacteria are more resistant to the lytic action of myxobacteria than the non-pigmented strains. Different species of myxobacteria and different strains of the same species differ in their lytic action on a number of species of bacteria.

The extracellular lytic substance produced by *Myxococcus virescens* passes through a cellophan membrane. A method of growing *M. fulvus* and *M. virescens* in mass cultures in liquid media to produce extracellular lytic secretions is described.

Department of Botany

BOOK

31. LONG, H. C., and BRENCHLEY, W. E. 1947. *Suppression of weeds by fertilisers and chemicals.* 2nd edition. pp. 87.

SCIENTIFIC AND TECHNICAL PAPERS

32. BRENCHLEY, W. E. 1947. *The toxic action of molybdenum in relation to soils and crops.* Ann. Appl. Biol., **35**, 139-160.

Attention has hitherto been focused on the harmful effect of molybdenum on animals, and there is comparatively little knowledge of the conditions in which molybdenum is poisonous to plants. There is evidence in the literature

that there are obvious differences in response to molybdenum poisoning in different soils, but no adequate reason has been put forward.

Tomatoes grown in ordinary loam showed little outward sign of poisoning with heavy doses of sodium molybdate, but some depression of crop occasionally occurred, especially when the dose was divided into early and late treatments. The response varied with season and variety. On certain light and fen soils the plants were killed at an early stage with the heavier dressing of molybdate, and seriously injured with the lighter dose, the leaves showing the golden colour characteristic of molybdenum poisoning in various plants.

The reaction of different crops varied considerably in the same soil with similar treatments. On old cucumber soil tomatoes showed no sign of toxicity even with the heavy dressing, flax was progressively damaged with increasing doses, while *Solanum nodiflorum* was most seriously affected even with the lighter dressing of molybdate. It was impossible to predict the reaction between soil, poison and crop without actual experiment.

The growth of flax was greatly impeded on a manganese deficient fen soil, and the molybdenum toxicity was masked in consequence. When the deficiency was corrected the poisonous effect of molybdenum on this soil was very marked, even with the lower dressing.

33. WARINGTON, K. 1947. *Molybdenum and its effect on growth of lettuce.* Victory Farm Forum, No. 27.

Lettuce grown in nutrient solution showed such marked benefit from the addition of 0·1 p.p.m. molybdenum that the element appears to be essential for normal healthy growth. In its absence the plants remained small and pale and developed a frill of withered leaves between the healthy inner and outer whorls. Excess molybdenum was harmful and 100 p.p.m. of the element caused serious injury. The poisonous effect was to some extent dependent on the variety of lettuce and the time of year at which it was grown, but no correlation between the molybdenum requirement of the plant and season was found.

34. BRENCHLEY, W. E. 1947. *The essential nature of certain minor elements for plant nutrition. II.* Bot. Rev., **13**, 169–193.

A review of the literature of minor elements in their relation to plants, following two similar reviews published in 1935 (Bot. Rev.) and 1943 (Biol. Rev.).

35. BRENCHLEY, W. E., and THURSTON, J. M. 1948. *Suggestions for the control of wild oats.* Agriculture, **51**, 12-16.

Information about methods that have been tried for the control of wild oats has been collected during the last year from various parts of the country, and the results are here summarized. Suggestions are also made for field experiments involving control by special methods of cultivation and cropping.

36. BRENCHLEY, W. E., and LONG, H. C. 1947. *Weeds of cornfields.* New Biology, **2**, 96–115.

A survey of the weeds specially associated with cereal crops and methods of cultural and chemical control.

REVIEWS BY W. E. BRENCHLEY

37. WHYTE, R. O. 1946. *Crop production and environment.* pp. 372. Faber and Faber. 25/– net. Agriculture, 1947, **LIV**, 333.

38. NELSON, A. 1946. *Principles of agricultural botany.* pp. 556. T. Nelson & Sons, Ltd. 35/–. Agriculture, 1947, **LIII**, 517.

Department of Crop Physiology

39. WATSON, D. J. 1947. *Comparative physiological studies on the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties, and within and between years.* Ann. Bot., N.S., **11**, 41–76.

Determinations of net assimilation rate (NAR) and of leaf area per plant or per metre of drill row were made at intervals throughout the growth of field-crops of wheat, barley, potatoes, mangolds, and sugar-beet at Rothamsted. Data are presented from 15 experiments in 6 years. The experiments included comparisons of varieties of the same crop and of sowings made on different dates.

Net assimilation rate showed similar variation with time in all years, rising during the spring months from very low values in winter to a maximum

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at midsummer, and subsequently falling during the late summer and autumn. This time trend is attributed to seasonal change in climatic factors. Deviations from a smooth time trend were found to be correlated with temperature deviations. The relation of NAR to temperature varied in different crops; for example, that of potatoes increased, while that of sugar-beet decreased, with increase in the mean daily temperature range. No significant correlation between NAR and mean daily radiation was detected.

Net assimilation rate measured for the same species over comparable calendar periods was found to vary from year to year. This annual variation may have been due partly to differences between years in climatic conditions, and partly to differences between fields in soil conditions. The existence of a seasonal time trend and of annual variation in NAR is evidence against the hypothesis that, apart from short-period fluctuations, NAR is independent of environmental conditions.

All the species tested were found to differ in NAR, when compared over the same calendar period in the same year. The rate increased in the order: wheat, barley, potatoes, mangolds, sugar-beet. At the extremes the NAR of sugar-beet was about twice that of wheat. Small but significant differences of NAR were also found between varieties of sugar-beet and potatoes, but not of wheat.

The net assimilation rate of sugar-beet was slightly increased by later sowing. This may imply that NAR declines with age, independently of change in external factors, but other explanations are possible. Autumn-sown and spring-sown wheat of the same variety differed little in NAR. These results show that variation of NAR with age plays little if any part in determining seasonal variation.

The leaf area per metre of drill row of wheat began to increase rapidly at about the time of maximum shoot number, reached its maximum in early June during the phase of shoot elongation when the shoots had attained about half their final height, and then decreased to zero at the end of July. The sequence of changes in the leaf area of barley was similar, but occurred later in the year; in contrast with wheat, leaf area and shoot number reached their maxima at about the same date, at the end of June. Potatoes attained their maximum leaf area per plant in August, and like cereals showed a rapid decrease of leaf area in the later stages of growth. The change with time in leaf area per plant of sugar-beet depended on the date of sowing. Early sowings produced their maximum leaf area in September, and subsequently there was a slow fall, but the leaf area of late sowings continued to increase into November.

Differences between years and between varieties in leaf area per plant of sugar-beet were mainly due to variation in leaf size and not in leaf number per plant. This was probably also true of wheat, but in potatoes, variation of leaf number also contributed to determine the differences between varieties in leaf area per plant.

Net assimilation rate was much less variable between years and between varieties of the same species than leaf area. Consequently the differences between years and varieties in yield of dry matter reflected mainly the differences in leaf area, and showed no close relation to the much smaller differences in NAR. Similarly, differences between species in yield of dry matter were accounted for almost completely by differences in leaf area, in spite of the wide variation in NAR between species. The reason is that in different species the production of leaf area occurred at different stages of the seasonal cycle of NAR. In general, variation in leaf area was the main factor determining differences in yield; variation in NAR was of minor importance.

40. WATSON, D. J. 1947. *Comparative physiological studies on the growth of field crops. II. The effect of varying nutrient supply on net assimilation rate and leaf area.* Ann. Bot., N.S., **11**, 375–407.

Growth analysis was used to investigate the physiological causes of variation in dry-matter yield produced by varied nutrient supply to crops of wheat, barley, and mangolds grown in 1939 on three of the classical field experiments at Rothamsted. In these experiments the same crop has been grown continuously on plots receiving varied annual fertiliser treatments, which have continued unchanged over a long period of years. Severe nutrient deficiency has developed on the plots where nutrients have been withheld, and the range of nutrient supply is consequently very wide. The experiments provide information on the effects of nitrogen in the form of sulphate of ammonia,

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phosphate, potash, a mixture of sodium and magnesium salts, farmyard manure, and of fallowing during the previous year.

Nitrogenous fertiliser consistently increased net assimilation rate (NAR). This effect was not restricted to the later stages of growth, and consequently cannot be attributed to delayed senescence of the leaves. In the early stages of growth nitrogen usually produced a greater increase of NAR in the presence of other nutrients than in their absence, but in the mangold experiment the addition of farmyard manure or potash caused a reduction in the esponser to nitrogen.

Fallowing causes an accumulation of nitrate in the soil and, like nitrogen supplied in the form of fertiliser, it increased NAR.

The effects of the other nutrients on NAR were smaller and more variable. Phosphate and potash reduced the NAR of wheat, while sodium and magnesium salts apparently increased it. Up to the time of maximum leaf area, all treatments increased the NAR of barley, and the effect of each was increased by the presence of the others. In the subsequent period the average effects of nitrogen, phosphate, and a combined dressing of potassium, sodium, and magnesium salts were all negative, but the interactions between the nutrients were large, possibly because deterioration of the photosynthetic mechanism was more rapid in the leaves of plants with unbalanced nutrient supply in the senescent phase preceding death of the whole plant. In the mangold experiment, phosphate, potash, and the mixture of sodium and magnesium salts all increased NAR in the period before maximum leaf area. Subsequently, the interactions were large compared with the main effects, as in the barley experiment, but it is doubtful whether this has any connexion with senescence or whether it was merely the result of increased sampling errors. In this period phosphate markedly reduced NAR, while potassium or sodium and magnesium salts increased it, when applied separately, but reduced it when applied together.

All treatments increased leaf area per metre or per plant, but the time at which the effects occurred, and the manner in which they were produced, differed with the different nutrients. In the cereal experiments, nitrogen increased both shoot number per metre and leaf area per shoot, so that its effect on leaf area per metre was apparent throughout the whole growth period. Phosphate increased shoot number, but had little effect on leaf area per shoot, tending to depress it in the later stages, presumably by hastening the death of the leaves. Potassium and sodium, on the other hand, had little effect on shoot number, but increased leaf area per shoot, possibly by prolonging the life of the leaves. Consequently, phosphate produced its greatest effect on leaf area per plant at an earlier stage of growth than potassium or sodium. In the mangold experiment nitrogen increased both leaf number and leaf size, and its effects continued to increase throughout the whole period of growth. The increases of leaf area produced by phosphate, potassium, and sodium were maximal in August and September, later falling to zero in October. Phosphate increased both leaf number and leaf size, but potassium and sodium had no effect on leaf number.

The effects of farmyard manure were similar to those of a fertiliser mixture supplying nitrogen, phosphate, and potash.

In general, the effects of varied nutrient supply were relatively greater on leaf area than on NAR; variation in dry-matter production caused by varying nutrient supply was mainly the result of changes in leaf area, and variation of NAR was of secondary importance. In some conditions, however, potassium and sodium produced a greater percentage increase in NAR than in leaf area. This may imply that potassium has special functions in relation to photosynthesis; if so, it appears that in mangolds these functions can also be fulfilled by sodium.

41. MORTON, A. G., and WATSON, D. J. *A physiological study of leaf growth.* Ann. Bot. (In the press.)

1. The effect of nitrogen, salt (NaCl), and water supply on leaf growth was investigated in two varieties of sugar beet grown in pot culture.

2. The rate of leaf production by the apical meristem was increased by increasing the external nitrogen supply but was unaffected by salt or water supply.

3. In one variety the number of cells in the individual leaf was increased by higher N and water supply, but decreased by salt. In the other variety water supply had no effect on cell number (N and salt not tested).

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4. Cell size varied considerably with water supply and other external conditions but no general conclusions can be drawn from the limited data available.

5. The number of cells in the leaf is greatly reduced when the initials arise in complete darkness, although such leaves are capable of normal cell extension if returned to light soon enough.

6. Effects of the treatments on yield and leaf area were examined. NAR was unaffected by external Nitrogen supply, although there was evidence that it is not independent of internal level of nitrogen.

7. Examination of field material shows that the effect of manurial treatment on cell number and cell size in the leaf varied considerably with different species.

42. CROOK, E. M., and WATSON, D. J. *Studies on the storage of potatoes. I. Changes in composition during storage in clamps.* J. Agric. Sci. (In the press.)

Changes in the percentage of dry matter, sugars, starch and nitrogen present in Arran Banner and Majestic potato tubers during storage in clamps until July were studied in two seasons. In the first season, the ascorbic acid content and the distribution of nitrogen between three fractions (insoluble, soluble coagulable, soluble non-coagulable) were also determined. In the second season, weighed samples of tubers were introduced into the clamps, so that changes in absolute amounts of the different constituents present in the tubers or sprouts could be measured. The effects of removing or retaining the soil cover on the clamps after early April were compared.

Dry matter per cent. of fresh weight in the tubers varied little during the early part of the storage period. After the removal of the soil cover in April, the dry matter content began to rise, but it decreased slightly if the soil was left on the clamp.

In the first season, sucrose and reducing sugars per cent. of dry matter both decreased slowly to a minimum in April, and subsequently there was a rapid rise. In the second season, the sucrose and reducing sugar contents increased between October and March; this was followed by a fall until May and a final rise. Starch per cent. of dry matter tended to fall as the storage period lengthened, but after sprouting began there was a temporary rise. Continuous records of the temperatures in the clamps were available for the second season, and it was shown that the rise and fall of sucrose content between October and May could be accounted for by the sensitivity of the starch, sugar balance to low temperatures, which causes potatoes to sweeten at temperatures below 6°C. The changes in reducing sugar content were less clearly correlated with temperature. The final rise of sugar content was attributed to internal changes associated with senescence.

There was no consistent time-trend in total nitrogen per cent. of dry matter. The insoluble nitrogen fraction was almost constant throughout storage, and the other fractions showed little change until the onset of sprouting, after which the soluble-coagulable fraction decreased and the soluble non-coagulable fraction increased. Ascorbic acid content increased during the early stages of storage to a maximum at about the time when sprouts began to appear, and then fell rapidly to a very low value at the end of the storage period.

The total weight of water present in the tubers declined throughout storage. In the clamp which retained its soil cover, 12 per cent. of the water initially present had been lost by July and 6 per cent. was recovered in the sprouts. Removal of the soil cover in April increased the water loss from the tubers to 27 per cent. and the recovery in the sprouts to 8 per cent.

There was no appreciable change in the total dry matter of the tubers until April, but, by July, 15 per cent. of initial dry matter had been lost, and a third of this was recovered in the sprouts. Removal of the soil cover had little effect on the dry matter changes.

The change with time in fresh weight of the tubers was determined mainly by loss of water. Thus, tubers in the clamp covered throughout storage lost 12 per cent. of their initial fresh weight by July, and of this 9 per cent. was contributed by water loss and 3 per cent. by dry matter loss. Removal of the soil cover doubled the loss of fresh weight, entirely by increasing water loss.

The total nitrogen content of the tubers decreased during storage by 10 per cent. of the initial value, and all the nitrogen loss was recovered in the sprouts.

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The total amounts of starch and residual dry matter (total dry matter less starch and sugars) in the tubers did not change appreciably between October and January, but in the following month 20 per cent. of the initial starch disappeared and residual dry matter increased correspondingly. The amount of starch then remained nearly constant until May, but subsequently it decreased rapidly and by July, only 60 per cent. of the initial starch remained in the tubers. Residual dry matter also remained nearly constant between February and April, tending to rise slightly, but in May most of the residual dry matter added in the previous three months was lost, and it was this change that caused the increase in starch as per cent. of dry matter at this time. At the end of the storage period residual dry matter increased again. These changes indicate a steady conversion of starch into some component of residual dry matter, proceeding rapidly during January and February, and then very slowly, possibly because of fall in temperature. With the onset of sprouting the change was temporarily reversed, but at the end of the storage period it was resumed at a more rapid rate. The whole of the loss of dry matter from the tubers during storage was at the expense of starch.

Cooking tests showed no appreciable change in the texture of boiled tubers until April, after which a rapid deterioration set in. This was apparently not directly connected with sprouting.

Department of Statistics

STATISTICAL METHODOLOGY

43. ANSCOMBE, F. J. 1948. *Sampling theory of negative binomial and logarithmic distributions.* Biometrika (In the press.)

(i) *Negative binomial distribution.* Remarks on the maximum-likelihood estimation of parameters. The efficiency of estimates of moment type. Mixtures of negative binomial distributions: the nature of the resulting distribution, a test for heterogeneity in the mean. The estimation of a common exponent k from a series of small samples with varying means. The treatment of field insect-population counts.

(ii) *Logarithmic series.* The error of estimation of the index of diversity α. Mixtures of logarithmic series: the nature of the resulting distribution, and test for heterogeneity in the mean.

(iii) Remarks on the compound binomial distributions corresponding to the above compound Poisson distributions.

(iv) Numerical examples.

44. ANSCOMBE, F. J. 1948. *The transformation of Poisson, binomial and negative binomial data.* Biometrika. (In the press.)

The asymptotic behaviour of a transformation (due to A. H. L. Johnson), $x=\sqrt{(r+\frac{3}{8})}$, of a Poisson variable r is shown. Analogous transformations are devised for binomial and negative binomial variables. Tables are given showing numerically the behaviour of the transformations for small values of the mean.

45. ANSCOMBE, F. J. 1948. *The validity of comparative experiments.* J. R. Statist. Soc. (In the press.)

An account of the logic of experimentation, the topics covered being: the effect of randomization on the analysis of an experiment; precautions other than randomization that can be taken to secure validity; current systems of inductive inference; the extent to which it is possible to draw valid conclusions from an experiment.

46. QUENOUILLE, M. H. 1947. *Notes on the calculation of autocorrelations of linear autoregressive schemes.* Biometrika, **34**, 365–367.

It is shown that the fundamental constants of autoregressive schemes can be calculated by an extension of the method of generating functions whereby inverse linear generating functions are used.

47. QUENOUILLE, M. H. 1948. *Some results in the testing of serial correlation coefficients.* Biometrika, **35.** (In the press.)

It is demonstrated mathematically that the serial correlation coefficients can with certain modifications be tested by the transformation used for the ordinary correlation coefficient. This result is tested numerically.

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48. QUENOUILLE, M. H. 1948. *A large-sample test for the goodness of fit of autoregressive schemes.* J. R. Statist. Soc., **110,** 123–129.

It is shown that a series of linear functions of serial correlation coefficients, which are in fact large sample distributions of partial correlations, can be used to test autoregressive schemes. It is also shown that superposed variations can be tested simultaneously.

49. QUENOUILLE, M. H. 1948. *The joint distribution of serial correlation coefficients.* Ann. Math. Statist., **19.** (In the press.)

The joint distribution of serial correlation coefficients defined circularly is investigated both when these are corrected and uncorrected for the mean. An exact distribution is obtained for the former case while an integral approximation is obtained in the latter.

50. QUENOUILLE, M. H. 1948. *The analysis of covariance and non-orthogonal comparisons.* Biometrics, **4.** (In the press.)

It is shown that when deviations from orthogonality are small, such as sometimes occur in field and animal experimentation and also in survey work, the usual process of fitting constants can be greatly simplified by the use of covariance analyses.

51. QUENOUILLE, M. H. 1948. *Problems in plane sampling.* Ann. Math. Statist. (In the press.)

The relative accuracy of different methods of sampling an area are investigated mathematically and expressions are derived for the types of correlation functions which normally occur. By this means the relative accuracies of systematic and stratified random sampling are investigated under different conditions. Numerical examples of the various methods of sampling are given.

52. QUENOUILLE, M. H. 1948. *The evaluation of probabilities in a normal multivariate distribution with special reference to the correlation ratio.* Edin. Math. Soc. (In the press.)

The large-sample distribution function of the correlation ratio is obtained and reduction formula and methods of evaluation are given.

53. QUENOUILLE, M. H. 1948. *A technique for the quantitative estimation of soil micro-organisms.* Statistical appendix to a paper by P. C. T. Jones and J. E. Mollison. J. Gen. Microbiol., **2,** 65–68.

It is shown that the distribution of bacteria per colony is logarithmic, the distribution of colonies per plate is Poisson and consequently that the distribution of bacteria per plate is negative binomial. Mathematical reasons for this are given and the appropriate numerical methods of analysis are investigated.

54. YATES, F. 1947. *The analysis of data from all possible reciprocal crosses of a group of strains.* Heredity, **1,** 287–301.

The paper describes the analysis of data obtained in plant breeding work when all possible reciprocal crosses between different lines are made. The cases discussed are: self-sterility, no self-sterility, self-sterility with incompatibility within groups of lines. The last case is illustrated by a numerical example.

55. YATES, F. 1947. *The analysis of contingency tables with groupings based on quantitative characters.* Biometrika, **35,** 176–181.

The paper deals with the analysis of a p x q contingency table in the case in which one or both groupings are based on characters which are either directly quantitative or are in the form of gradings which can be regarded as having an underlying quantitative basis. The method of analysis is illustrated by a numerical example.

56. YATES, F. 1948. *Systematic sampling.* Phil. Trans. (In the press.)

This paper gives an account of the results of an investigation into one-dimensional systematic sampling, i.e., the sampling of sequences of quantitative values by the use of sampling points equally spaced along the sequence. New methods, using what are termed partial systematic samples, are evolved for estimating the systematic sampling error from short sections of sequences of completely enumerated numerical material. Simple end-corrections are proposed for eliminating the errors, due to trend, which are otherwise inherent in randomly located systematic samples. It is demonstrated that it is impossible to make any fully reliable estimate of the sampling error from the systematic sampling results themselves, though if the continuous components

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of variation are not too marked, the sum of sets of terms taken alternately positive and negative, with suitable end adjustments, will provide a moderately satisfactory estimate, which will always be an overestimate provided there are no periodicities. This estimate is substantially better than the customary estimate based on successive differences. In other cases supplementary sampling is required to furnish an estimate of error, and methods are described whereby estimates can be derived from supplementary samples at half spacing, or at half and quarter spacing. The performance of systematic sampling is investigated theoretically for certain mathematical functions, and also by the numerical analysis of certain numerical sequences. The relation between the gain in precision and the gain in efficiency is evaluated.

REPORTS OF STATISTICAL INVESTIGATIONS

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

An analysis of the edibility of 87 strains of soil bacteria, of various types, by eight micro-predators. These micro-predators show some association in choice of prey, as if some bacterial strains are more intrinsically edible to the micro-predators than others.

58. BOYD, D. A., and MATHISON, I. 1947. *Fertiliser application: findings of the Survey of Fertiliser Practice.* Agriculture, **54,** 325–328.

A summary is given of information on the use of combine drills obtained by the Survey of Fertiliser Practice. Only in the Eastern and South-Eastern provinces was more than half the phosphate fertiliser applied by combine drill, and even in these provinces combine drills were relatively uncommon in some of the more backward districts. In the west and north of the country the distribution of combine drills was sporadic, but generally speaking they were used on only a very small percentage of the farms. In all districts there was a marked tendency for the combine drills to be employed on the larger farms. While farms using combine drills used much the same total amount of fertiliser as farms which broadcast their fertiliser, the proportion of the acreage dressed was higher by about one-third on the combine drill farms.

The only surveyed area where combine drilling of root crops was at all common was the fen part of Huntingdonshire and the Isle of Ely, where a considerable proportion of the carrots, sugar beet and mangolds are drilled in this way.

SUMMARIES, REVIEWS, ETC.

59. YATES, F. 1947. *The influence of agricultural research statistics on the development of sampling theory.* Paper read at International Statistical Conference, Washington. (In the press.)

60. YATES, F. 1947. *Technique of the analysis of variance.* Nature, **160,** 472 (correspondence).

61. YATES, F. 1948. THIONET, P. *Methodes statistiques modernes des administrations fédérales aux Etats-Unis.* (Review.) Nature, **161,** 153.

Department of Plant Pathology

BOOK

62. BAWDEN, F. C. 1948. *Plant diseases.* Edinburgh, Nelson.

GENERAL ARTICLES

63. BAWDEN, F. C. 1948. *Some implications and limitations of recent work on plant viruses.* Proc. 4th Inter. Cong. for Microbiology.

64. SHEFFIELD, F. M. L. 1948. *The virus in the plant cell.* Proc. 6th Inter. Cong. for Exptl. Cytology, Stockholm.

65. ———. 1948. *Some cytological studies of virus infected plants.* Proc. 7th Meeting E. M. group of the Instit. Phys.

66. GARRETT, S. D., and BUDDIN, W. 1947. *Control of take-all under the Chamberlain system of intensive barley growing.* Agriculture, **54,** 425–26.

67. WATSON, M. A. 1947. *Some aspects of the epidemiology of the yellows and mosaic diseases of sugar beet.* Prof. Conf. Int. de Rech. Betteraveries.

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RESEARCH BULLETIN

68. DONCASTER, J. P., and GREGORY, P. H. 1948. *The spread of virus diseases in the potato crop.* A. R. C. Report series No. 7, London H.M. Stationery Office.

RESEARCH PAPERS

69. BAWDEN, F. C., and CROOK, E. M. 1947. *Some properties of potato virus* X *in leaf extracts made in different ways.* Brit. J. Exp. Path., **28**, 403.

By incubating fibrous residues from leaves infected with potato virus X with enzymes from the alimentary tract of snails, as much virus is obtained as occurs in sap. About 4 per cent. of the virus extracted by snail enzymes is released by grinding the fibre finely in a triple-roller mill.

The virus in the different kinds of extracts does not differ greatly in infectivity, but the sizes of particles vary widely. The particles in mill extracts are short and give somatic-type precipitin reactions. In snail extracts, the particles are greatly elongated; in freshly-extracted sap particle length is variable but the average is greater than in mill extracts; both extracts give typical flagellar type precipitin reactions. The virus particles in sap vary in length and readily aggregate linearly.

Incubating mill extracts with healthy plant sap or trypsin causes the small particles to aggregate and changes their precipitin reaction from somatic to flagellar type.

Virus X in mill extracts or in purified preparations, but not in sap, is inactivated by incubation with pH 7 phosphate buffer and chloroform. This inactivation is prevented by snail enzyme preparations, healthy leaf sap and some other protein-containing solutions.

The virus content of infected plants varies with different hosts and virus strains. The largest was found with X^k in tomatoes, where the virus amounted to 2 per cent. of the dry weight of the leaves. There is no unequivocal evidence on either the size of the particles as they exist in the host cells or the relationship between the virus occurring in sap and that remaining in the fibrous residues.

70. BAWDEN, F. C., and KLECZKOWSKI, A. 1948. *Variations in the properties of potato virus* X *and their effects on its interactions with ribonuclease and proteolytic enzymes.* J. Gen. Microbiol., **2**, 173.

When concentrated by precipitation with acid and salts, or by high-speed centrifugation, potato virus X tends to become insoluble though still remaining infective and serologically active. This greatly complicates purification and no method was found that could be relied upon to give good yields of virus with constant properties. Insolubility is correlated with the aggregation of virus particles to form long threads that become entangled, but it is probable that combination of the particles with some cell constituents is also concerned.

Insoluble preparations dissolve slowly when incubated with pH 7 boric acid buffer, and rapidly in the presence of trypsin and chymotrypsin. Both of these enzymes hydrolyse virus X, chymotrypsin being more effective, but different strains of the virus vary in susceptibility.

Ribonuclease readily hydrolyses the nucleic acid derived from virus X, but seems to have no enzymic action on the active virus. When mixed with the virus, the enzyme combines with it and reversibly inhibits infectivity. At pH 7 the addition of ribonuclease to soluble virus preparations causes loss of anisotropy of flow, a fall in precipitin titre, and the production of an insoluble complex. Incubation at pH 7·5 with boric buffer slowly dissolves the complex and restores the original properties of the virus; the rate of re-solution is increased by the presence of trypsin. Some preparations of the virus were partially decomposed by incubation with boric buffer, and sometimes the rate of decomposition was increased in the presence of ribonuclease.

71. BAWDEN, F. C., KASSANIS, B., and ROBERTS, F. M. 1948. *Studies on the importance and control of potato virus* X. Ann. Appl. Biol., **35**, 250.

The success of seed certification schemes in controlling the aphis-transmitted viruses that cause leaf roll and rugose mosaic has greatly

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increased the relative importance of potato virus X, in spite of the value of such schemes in reducing the prevalence of the most virulent strains. Virus X occurs throughout commercial stocks of most varieties and is responsible for many of the uncertainties and difficulties encountered in field inspections, for the production of leaf symptoms by many strains depends on the weather. Also, the predominating virus strain in a stock may change from season to season.

Methods of testing for the presence of avirulent strains in potatoes are described. These include transmission to suitable indicator plants, plant protection tests, and serological methods. The virus content of different parts of the plant varies widely, but in all is high enough for transmission to indicator plants at all times of the year. The virus content of immature tubers is too low to give a precipitin reaction, but extracts from developing sprouts contain nearly as much as those from foliage, and can be used reliably.

Infection of virus-free stocks of the varieties Majestic and Arran Banner with four different strains of virus X reduced their yields by amounts varying from 5 per cent. to 24 per cent. Scotch Stock Seed Majestic, however, cropped better than the virus-free seed, and the need for considering additional factors to freedom from viruses when selecting clonal lines for propagation is stressed.

Virus X was not transmitted by cutting healthy tubers with a knife previously used to cut infected ones, and cut tubers whose storage parenchyma was rubbed with infective sap gave rise to virus-free plants. Infection occurred when sprouts were rubbed with infective sap and the virus also spread from infected to healthy sprouted tubers stored in the same sack.

Spread of the virus under natural conditions is slow and it is concluded that the maintenance of virus-free stocks under commercial conditions is feasible, provided that precautions are taken to prevent contact with infected plants. The relative importance of volunteer plants and other sources of infection is discussed, and methods of testing the virus-free stocks are suggested.

72. BAWDEN, F. C., and KASSANIS, B. 1947. *The behaviour of some naturally occurring strains of potato virus Y.* Ann. Appl. Biol., **34**, 503.

Potato virus Y was obtained from field crops of potatoes in many strains which differed widely in virulence and caused diseases in the variety Majestic ranging from severe leaf-drop-streak to mild mosaic. The symptoms caused by these strains in seven potato varieties and tobacco are described and compared with those caused by the serologically related potato virus C. No changes were noted in the behaviour of any of the strains over three years, during which they were transmitted to many different plants.

Potato virus C was not transmitted by *Myzus persicae*, the most efficient vector of other strains of virus Y. Nor was virus C transmitted by 11 other species of aphides, 8 of which transmitted virus Y. The efficiency with which different species acted as vectors of virus Y varied greatly, and it is suggested that in some species only occasional individuals can transmit.

Possible mechanisms for the evolution of viruses C and Y are indicated, and the effects of changes in virus, vector and host, on the prevalence of insect-transmitted viruses are discussed.

73. BROADBENT, L. 1947. *Aphides overwintering as viviparae in roo clamps.* Ent. Mon. Mag., **83**, 178.

A note recording a new overwintering site for *Myzus persicae* and other aphides.

74. BROADBENT, L. 1947. *An analysis of captures of Aphididae (Hemiptera) in a light trap.* Trans. R. Ent. Soc. Lond., **98**, 475–90.

Four years' captures of aphides in a light trap are analysed, on arithmetic and logarithmic bases, month by month and throughout the night. It is shown that aphides were flying during the night in each month from May to November. An attempt is made to correlate the captures of one summer with the various meteorological factors prevailing; activity was positively correlated with the maximum temperature of the previous day and with the evening reading of the dew point; it was negatively correlated with the wind force of the previous afternoon, and wind direction also had a significant effect. Population changes from year to year were probably dependent to a great extent on the summer rainfall, the population being lower in wet years.

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75. BROADBENT, L., and HULL, R. 1947. *Aphides in root clamps.* Agriculture, **54**, 319–22.

A survey of mangold and swede clamps infested with aphides is described. The numbers of *M. persicae* in the clamps was affected by harvesting and clamping methods. The potential danger of infested clamps as sources of spring migrant aphides is stressed, especially as sugar beet yellows virus is common also in mangolds.

76. GARRETT, S. D. 1948. *Soil conditions and the take-all disease of wheat. IX. Interaction between host plant nutrition, disease escape, and disease resistance.* Ann. Appl. Biol., **35**, 14–17.

In a field experiment the Disease Rating of the roots of barley plants suffering from take-all was reduced by application of nitrogen, and by a combined dressing of phosphate and potash. This reduction is attributed to the fact that manuring enables the cereal plant to produce new crown roots more quickly than *Ophiobolus graminis* can infect them. In an earlier pot culture experiment, operation of this disease escape mechanism was inadvertently reduced to a minimum by inoculating plants at the crown, and by environmental conditions exceptionally favourable to infection (sand culture and relatively high temperatures in the glasshouse). Under these conditions, not only was root Disease Rating as high in the series receiving a full supply of nutrients (NPK) as in that receiving only one-third the full amount, but it was even reduced, almost to one-half, in the series receiving one-third nitrogen in the presence of full phosphate and potash (PK 1/3 N). It is concluded, therefore, that an increase in nitrogen supply may increase the intrinsic susceptibility of individual roots to infection, at the same time as it promotes disease escape and increased yield of the whole plant.

77. 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.

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 48 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. Ploughing-in straw in autumn increased 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.

78. GREGORY, P. H. *de Bary's description and specimen of* Peziza fuckelinana. Trans. Brit. Mycol. Soc. (In the press.)

Interest in *Sclerotinia Fuckeliana*, described by de Bary as the perfect stage of *Botrytis cinerea* on vine, is revived by the production of apothecia in pure cultures by Drayton and Groves. The identification of these apothecia has been hindred by lack of information on de Bary's fungus, the reference usually cited as a description being a *nomen nudum*.

The various descriptions of this fungus are cited, including a detailed account and figure by de Bary, which appear hitherto have been overlooked. Photographs are also given of de Bary's slide of *S. Fuckeliana* from the British Museum (Natural History), which evidently constitutes the type specimen. The information now available should help to determine the position of apothecia produced in pure culture.

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79. GREGORY, P. H. *The operation of the puff-ball mechanism of* Lycoperdon perlatum *by raindrops shown by ultra-high-speed Schlieren cinematography.* Trans. Brit. Mycol. Soc.

Spore discharge from puff-balls of the *Lycoperdon perlatum* type can be brought about by impact of water drops with the flattened papery top of the endoperidium. Rain drops of 1 mm. diameter or over, and rain-drip from trees are adequate to operate the mechanism. Analysis of the operation by ultra-high-speed photographs shows that the puff reaches a height of a centimetre in approximately one hundredth of a second after impact. The velocity of the puff on emerging from the ostiole is of the order of 100 cm. per second.

The endoperidium of *L. perlatum* is normally waterproof and ejection continues under humid conditions. Estimates, made from meteorological data, show that a fruit body must be operated many thousands of times in a season. It is concluded that rain drop impact is efficient in liberating spores from *L. perlatum*.

80. HULL, R. 1947. *Healthy sugar beet.* Agriculture, **54**, 7–21.

Practical measures which may be taken to avoid disease infection in sugar beet crops are described.

81. HULL, R., and WATSON, M. A. 1947. *Factors affecting the loss of yield of sugar beet caused by beet yellows virus. II. Nutrition and variety.* J. Agric. Sci., **37**, 301.

The losses caused by infection increased proportionally as the mean yield increased through fertiliser applications. Fertiliser treatments did not greatly affect the rate of spread of the disease. None of the commercial varieties or the breeders lines which were tested were found to be materially more tolerant than others to the virus.

82. KASSANIS, B., and KLECZKOWSKI, A. 1948. *The isolation and some properties of a virus-inhibiting protein from* Phytolacca esculenta. J. Gen. Microbiol., **2**, 143.

An inhibitor of plant viruses can be isolated from the sap of *Phytolacca esculenta* by differential precipitation with ethanol followed by adsorption on celite and elution with 10 per cent. NaCl. Purified preparations contain 14-15 per cent. nitrogen and 8-12 per cent. carbohydrate, and the inhibitor is probably a glycoprotein. Denaturation leads to loss of inhibiting power. The protein is unaffected by pepsin and trypsin, unless denatured.

The glycoprotein is isoelectric at about pH 7. It can combine with tobacco mosaic virus, and when salt-free solutions of the two are mixed in certain proportions at pH values between their isoelectric points it precipitates the virus in the form of paracrystalline threads. The glycoprotein also precipitates tomato bushy stunt virus.

When added to several plant viruses the glycoprotein causes an immediate reduction in infectivity, but has no effect on a bacteriophage. Non-infective mixtures regain infectivity when diluted. No evidence was found for a combining ratio of virus to inhibitor necessary to cause loss of infectivity. The mechanism of virus-neutralization is discussed.

83. KASSANIS, B., and SELMAN, I. W. 1947. *Variations in the reaction of White Burley tobacco to strains of tobacco mosaic virus.* J. of Pom. and Hort. Sci., **23**, 167.

White Burley tobacco exists in two distinct lines as shown by reactions to some strains of tobacco mosaic virus. The two are similar morphologically, but one line produces necrotic local lesions with tomato aucuba mosaic virus whereas the other line produces a systemic yellow mottle. In the lines in which tomato aucuba mosaic produces necrosis some other strains of tobacco virus also react necrotically.

84. KLECZKOWSKI, A. 1948. *Proteolytic activity of preparations of crystallized ribonuclease.* Biochem. J., **42**, 523-27.

Crystalline preparations of ribonuclease invariably possessed proteolytic activity, which varied in amount in different preparations. The proteolytic and ribonuclease activities occur in somewhat different pH zones, and incubation between pH 4·0 and 4·5 gives ribonuclease activity alone, though in this zone it is far from its optimum.

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By heating at pH 7·0–7·5 in specified conditions, the proteolytic activity can be greatly reduced or destroyed, while leaving between 80 per cent. and 30 per cent. of the original ribonuclease activity.

Ribonuclease is susceptible to both pepsin and chymotrypsin, but it is hydrolysed much more repidly by pepsin. The proteolytic enzyme present in crystalline preparations of ribonuclease also hydrolyses ribonuclease.

85. ROBERTS, F. M. 1948. *Experiments on the spread of potato virus X between plants in contact.* Ann. Appl. Biol. **35,** 266.

Experiments on the spread of five strains of potato virus X were made with seven potato varieties and with tomato plants both under glass and in the field. Spread by leaf contact between healthy and infected plants was confirmed and it was also found that spread could occur between plants whose only contact was below ground.

The rate of spread was much greater in tomato than in potato plants, and virulent strains of the virus, which achieve a high concentration in infected plants, spread more rapidly than avirulent strains. In only one experiment with potatoes did more than 10 per cent. of the healthy potato plants exposed to infection become infected during one season.

Datura stramonium and tomato plants became infected when growing in soil containing sap or residue from X-infected plants.

It was common in the field for potato plants whose foliage gave no reaction for virus X at the end of the season to yield a mixed progeny of healthy and infected tubers. Such infections are thought to result from underground spread.

Attempts to transmit virus X from infected to healthy potatoes by means of *Rhizoctonia solani* failed. No examples of infection were found except when healthy plants came into direct contact with sources of the virus.

Department of Biochemistry

86. ROBERTSON, NOEL, and MACFARLANE, Ian. 1946. *The occurrence of perithecia of the oak mildew in Britain.* Trans. Brit. Myc. Soc., **24,** 119–20.

87. BREMNER, J. M., HEINTZE, S. G., MANN, P. J. G., and LEES, H. 1946. *Metallo-organic complexes in soil.* Nature, **158,** 790.

88. HEINTZE, S. G., and MANN, P. J. G. 1946. *Divalent manganese in soil extracts.* Nature, **158,** 791.

89. HEINTZE, S. G., and MANN, P. J. G. 1947. *Soluble complexes of manganic manganese.* J. Agric. Sci., **37,** 23.

90. HOLDEN, M. 1948. *An alkali producing mechanism in macerated* leaves. Biochem. J., **42,** 332.

91. HOLDEN, M., and TRACEY, M. V. 1948. *The effect of fertilisers on the levels of Nitrogen Phosphorus, Protease and Pectase in healthy tobacco leaves.* Biochem. J., **43,** 147.

92. 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 fertilisers.* Biochem. J., **43,** 151.

93. LEES, H. 1947. *A simple automatic percolator.* J. Agric. Sci., **37,** 27.

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

95. PATERSON, J. S., PIRIE, N. W., and STABLEFORTH, A. W. 1947. *Protective antigens isolated from Brucella abortus.* Brit. J. Exp. Path., **28,** 223.

96. PIRIE, N. W. 1947. *The state of viruses in the infected cell.* Cold Spring Harbour symposia on quantitative biology, **9,** 184.

97. PIRIE, N. W. 1947. *What is a dialysate?* Nature, **160,** 198.

98. PIRIE, N. W. 1947. *Leaf protein.* Food Manufacture, **22,** 493.

99. PIRIE, N. W. 1948. *The nature and development of life and of our ideas about it.* Modern Quarterly, **3,** 82.

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100. PIRIE, N. W., and HADIDIAN, Z. 1948. *The preparation and some properties of hyaluronic acid from human umbilical cord.* Biochem. J., **42,** 260.

101. PIRIE, N. W., and HADIDIAN, Z. 1948. *The effects of serum and of hyaluronic acid derivatives on the action of hyaluronidase.* Biochemical J., **42,** 266.

102. TRACEY, M. V. *A possible role of d-amino-acids.* Biochem. Symposia, **1,** 89.

103. TRACEY, M. V. 1948. *Leaf protease of tobacco and other plants.* Biochem. J., **42,** 281.

104. TRACEY, M. V. 1948. *A manometric method for the estimation of small quantities of uronic acids.* Biochem. J., **43,** 185.

PUBLICATIONS IN THE PRESS

105. CROOK, E. M., and HOLDEN, M. *Some factors affecting the extraction of nitrogenous materials from leaves of various species.*

106. PIRIE, N. W. *The development of our ideas on the nature of viruses.*

107. PIRIE, N. W. *The combination of viruses with other materials in the infected cell and in extracts.*

108. TRACEY, M. V. *Human biochemical genetics.*

109. TRACEY, M. V. *Proteins and life.*

Department of Entomology

110. BARNES, H. F. 1947. *Periodic Fluctuations in the Prevalence of the Wheat Blossom Midges.* J. Animal Ecol., **16, 74–5.**

A note giving details of the rhythmic fluctuations in the numbers of the wheat blossom midges infesting the wheat on Broadbalk during the twenty years 1927–46. There have been two major peaks of infestation in 1931 and 1946 with two minor peaks in 1935 or 6 and 1941.

111. CERNOSVITOV, L., and EVANS, A. C. 1947. *Lumbricidae, No.* 6 *of Synopses of the British Fauna.* The Linnean Society, 36 pp.
Descriptions of and key to the British species.

112. EVANS, A. C., and GUILD, W. J. McL. 1947. *Studies on the relationships between earthworms and soil fertility. I. Biological studies in the field.* Ann. Appl. Biol., **34,** 307–330.

Changes in the seasonal activity of several species of earthworms have been followed in a permanent pasture field for 18 months, 1945–6. The two soil conditions which chiefly determine activity are temperature and moisture. Other factors are the occurrence of an obligatory diapause in the two species *Allolobophora nocturna* and *A. longa*, and changes in population in *A. chlorotica* and *Lumbricus terrestris*.

Soil temperature and soil moisture also determined the weight of soil thrown up in the form of wormcasts during autumn, winter and spring. It is suggested that only two species, *A. nocturna* and *A. longa* are responsible for wormcasts and that the other four common species present play little or no part in this activity.

At Rothamsted it was found that the previous agricultural history of the field is an important factor in determining the fauna. Old permanent pasture is characterized by a high percentage of *A. nocturna* and a rather lower percentage of *A. caliginosa*. Ploughing old permanent pasture and reseeding to grass after 1 or 2 years arable reduces the proportions of *A. nocturna* and *A. caliginosa* and increases that of *Eisenia rosea*. Arable fields have *A. chlorotica* as the dominant species and pasture fields 2–7 years grass after many years of arable farming still show a high percentage of *chlorotica* and a low proportion of *A. nocturna*.

A survey of the Carse of Stirling, Scotland, showed that soil type is also an important factor in determining the earthworm fauna. *A. caliginosa* was the dominant species on the three soil types studied, but the subdominant species varied. On clay soil, *A. longa* was subdominant; on loam, *A. longa* and *L. rubellus*; on sandy soil, *A. longa*, *L. rubellus* and *A. chlorotica*. The dominant species of pasture land at Rothamsted, *A. nocturna*, was not found at Stirling.

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113. EVANS, A. C. 1948. *II. Some effects of earthworms on soil structure.* Ann. Appl. Biol., **35**, 1-13.

The weight of wormcasts thrown on to the surface of eight fields of differing agricultural history depends on the numbers of *Allolobophora longa* Ude and *A. nocturna* Evans present and also on the mean size of the individuals of these two species. The weight of wormcasts produced per acre per annum on the different fields varied from 1–25 tons, and it is calculated that from 4–36 tons of soil per acre per annum pass through the alimentary tracts of the total population of earthworms present. The percentage pore space of a soil containing a high population of worm-casting species is much greater than that of a field with a high population of worms which do not produce wormcasts. The amount of coarse sand relative to silt and clay increases appreciably with depth in two old pastures; this distribution is probably a result of the long continued activity of earthworms.

114. GUILD, W. J. McL. 1948. *III. The effect of soil type on the structure of earthworm populations.* Ann. Appl. Biol., **35**, 181-192.

Sampling on several soil types, in Scotland, have shown that the earthworm populations differ in number and composition. Light and medium loams carry higher populations than the heavier clay or more open alluvial or sandy-gravel types. The genus *Allolobophora* is the most numerous on all types, *A. caliginosa* being the dominant species. *The Lumbricus* spp. are relatively more numerous on the alluvial and sandy-gravel types.

Natural hill pasture contains a smaller population than limed and fertilised pasture, and the species present are mainly small types. As natural pasture is brought under agricultural treatment the population increases and species typical of good pasture land become established.

115. EVANS, A. C., and GUILD, W. J. McL. *IV. The life-cycles of some British earthworms.*

The rate of cocoon production differs considerably from species to species and is greatly affected by soil temperature, moisture and the food supply of the adult worms. Only two out of fourteen species studied frequently produced more than one worm per cocoon and twins were only recorded once in many hundreds of observations on four species of the genus *Lumbricus*.

116. EVANS, A. C., and GUILD, W. J. McL. *V. Field populations.* Accepted for Ann. Appl. Biol.

The ploughing of a permanent pasture in spring was not followed by a reduction of the earthworm population during the first six months. Further arable cultivation does greatly reduce the population. Leys four to seven years old carry a total population similar to that of permanent pastures but with differing proportions of certain species. Some trends in population changes during a period of nearly one year are described for five common species. The population of a permanent pasture did not show appreciable change for a period of nearly three years but that of a ley, in its first year following arable, showed a significant increase.

117. EVANS, A. C. 1947. *Earthworms.* J. Bd. Greenk. Res., **7**, 49–54.

A popular summary.

118. EVANS, A. C. 1946. *A new species of earthworm of the genus* Allolobophora. Ann. Mag. Nat. Hist. Ser. 11, **13**, 98–101.

One of the commonest worms found on permanent pastures at Rothamsted was found to be a new species.

119. EVANS, A. C., and GUILD, W. J. McL. *The cocoons of British earthworms.* (In MSS.) *Some notes on reproduction in British earthworms.* (In MSS.)

Descriptions of the cocoons of seventeen species.

120. EVANS, A. C. *On segment number and regeneration in earthworms.* (In MSS.)

Earthworms possess a characteristic segment number which is sometimes of systematic value. The mean segment number of field populations is sometimes lower than that of the true value as a result of damage by predators. Some species emerge from the cocoon with the full number of segments already formed, others with a lower number. A study of the mean number of segments possessed by field populations from different areas suggests that the degree of predator attack may vary considerably. It is

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suggested that posterior regeneration does not occur in the following genera, *Lumbricus* and *Octolasium*, and possibly not in *Dendroboena*, *Eiseniella* and *Bimastus*.

121. Evans, A. C. *On some earthworms from Iowa.* (In MSS.)
The dominant species present were of European origin, one new species was described.

122. Evans, A. C. *The identity of earthworms stored by moles.* (In MSS.)
Earthworms stored by moles consist chiefly of *L. terrestris*.

123. Evans, A. C. *The burrow systems of earthworms.* (In MSS.)
Earthworms of the genus *Lumbricus* appear to inhabit simple U-shaped burrows until the available supply of food on the surface is exhausted. When this occurs they burrow extensively into the surface soil and drive burrows deeply into the subsoil. *A. caliginosa* burrows extensively in the surface soil even though ample supplies of food are present on the surface.

124. Evans, A. C. 1947. *New facts about earthworms.* The Countryman.
A popular resumé.

125. Evans, A. C. 1948. *Earthworms and the soil.* Discovery.
A popular resumé.

126. Evans, A. C. 1948. *Earthworms and the farmer.* Farming.
A popular resumé.

127. Williams, C. B. 1947. *The field of research in preventive entomology.* Ann. Appl. Biol., **34**, 175–185.
An important branch of agricultural Entomology is that which is concerned with the causes of insect outbreaks and the possibility of anticipating and preventing them. The problems concerned are the environment factors which affect birth rate, death rate, length of life, and movement. The field of research can be roughly divided into the following branches:—

Factors affecting the total population.
The Physical environment
Geology and Geography
Climate and weather
The Biological environment
Food supply
Parasites and Predators
Competition.
Factors affecting the distribution of populations.
Migration, or deliberate movement
Drift, or accidental movement by natural causes
Accidental distribution by human agency.

Each of them is briefly summarized with examples and an appeal is made for more extensive work in applied ecology of insects.

128. Williams, C. B. 1947. *The generic relations of species in small ecological communities.* Journ. Anim. Ecol., **16**, 11–18.
Evidence had previously been brought forward to show that in large groups of animals or plants the number of genera with 1, 2, and with 3 and more species are closely represented by the mathematical "logarithmic series". New evidence is here given to show that the same order exists in the genera and species of quite small ecological communities.
The logarithmic series has several mathematical properties of biological interest, including the possibility of calculating, for any population or sample, a factor known as the "Index of Diversity" which is common to all random samples from a single population. It is a measure of the extent to which the species are grouped into genera, and it is independent of the size of the sample. If the Index of Diversity is high, there are many genera in relation to the number of species; if the Index is low, there are fewer genera in relation to the number of species.
It thus becomes possible to compare the Index of Diversity in natural small or simple ecological communities, with that of the larger population from which these have been selected by nature. This has been done for a number of cases, including both animal and plant communities, and in every case from which significant results can be obtained the Index of Diversity in the small community is smaller than that of the larger fauna or flora.

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The result therefore indicates that there are fewer genera in a small or simple community than would be expected in a sample of the same number of species selected at random—that is, independent of generic relationships—from the larger series. In other words, the evidence brought forward by this method indicates a selection by nature in favour of more than one species in the same genus rather than in favour of single species in different genera.

Bee Department

129. BUTLER, C. G. 1946. *Bee culture and research in the U.S.A.* Ann. Rept. Central Assoc. of B.B.K.A., 2–10.

A brief report on a visit made to North America and of bee research work in progress in the Federal and some State laboratories. Particular reference is paid to work on artificial insemination of queen honeybees; the resistance of certain strains of bees to American Foul Brood: European Foul Brood: the sulphonamide treatment for American Foul Brood.

130. BUTLER, C. G. 1947. *An introduction to Beekeeping.* Daily Mail School-Aid Booklet.

131. BUTLER, C. G. 1947. *Beehives.* Ministry of Agriculture and Fisheries Bulletin. (In the press.)

132. BUTLER, C. G. 1947. *Some trends of bee research to-day.* J. Dept. Agric. Scotland. (In the press.)

133. MILNE, P. S. 1947. *Sulphonamide treatment of American Foul Brood.* Agriculture, **54,** 82–87.

A summary of the experiments with various sulphonamides that have been carried out at Rothamsted and at number of outside centres.

134. RIBBANDS, C. R. 1947. *Some foraging methods of individual honeybees.* (Prepared for publication.)

Observations made upon the movements and behaviour of individual honeybees when collecting food, particularly pollen, in a specially planted experimental garden. It is concluded that worker honeybees exhibit a pattern of trial and error learning of considerable complexity.

135. SYNGE, A. D. 1947. *Pollen collection by honeybees* (Apis mellifera). J. Animal Ecology, **16.**

A study of the species of plants from the flowers of which honeybees in an apiary on the Rothamsted Experimental Farm collected their pollen during 1945 and 1946. It was found that approximately 95 per cent. of all the pollen collected was obtained from about 20 species of plants and that the clovers alone yielded almost 50 per cent. The availability of pollen in various species of flowers was also investigated.

Department of Insecticides

136. MCINTOSH, A. H. 1947. *A dipping apparatus for estimating the toxicity of insecticides in liquid media.* Ann. Appl. Biol., **34,** 233–239.

An apparatus and a technique are described for the study of the effect of liquid insecticidal preparations by dipping insects in the toxic material. The method is applicable to quick-settling suspensions and quick-creaming emulsions as well as to solutions. Dipping is performed at constant temperature with end-over-end shaking; and the technique has the advantage over the other dipping methods that have been described in that handling of individual insects whilst wet is eliminated.

137. LORD, K. A., and JOHNSON, C. G. 1947. *The production of dermatitis by pyrethrum and attempts to produce a non-irritant extract.* Brit. J. Dermatology & Syphilis, **59,** 367–375.

The production of dermatitis in both men and women by continual application of pyrethrum creams is described.

The preparation of pyrethrin concentrates by chromatographic adsorption is also described. Tests on the irritant properties of these preparations suggest that petroleum ether and ethylene dichloride wash out the pyrethrins preferentially from a column of fullers earth which retains the dermatitis-producing factor. The amount of dermatitis producing factor present in some of the preparations appeared to be much lower than that contained in a commercial concentrate.

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138. BRAY, G. T., HARPER, S. H., LORD, K. A., MAJOR, F., and TRESADERN, F. H. 1947. *The determination of the factor for pyrethrin I in the mercury method.*. J. Soc. Chem. Ind., **66**, 275–279.

The authors have examined in two series of experiments the effect of varying the conditions under which the reduction of Deniges reagent by chrysanthemum monocarboxylic acid is allowed to proceed. They have shown that both temperature and time of reaction influence appreciably the extent of the reduction; and have confirmed the result previously obtained by Graham and LaForge, that 1 ml. 0·01 M-potassium iodate solution is equivalent to 5·7 mg. pyrethrin I when the reduction takes place at 25 ± 2° for 1 hour. Differences of 5–6 per cent. of the general mean value were shown in the second series despite careful standardisation of conditions.

139. HARPER, S. H., POTTER, C., and GILLHAM E. M. 1947. *Annona species as insecticides.* Ann. Appl. Biol., **34**, 104–112.

By extraction and precipitation from several solvents the toxic principle present in *Annona reticulata* and *A. squamosa* seeds and roots has been concentrated up to one hundredfold. A preliminary chemical examination of this concentrate is described, leading to the conclusion that the toxicity is due to a glyceride or glycerides of a hydroxylated unsaturated acid or acids of high molecular weight.

These extracts have been examined for contact and stomach poison and ovicidal properties in a variety of media. When used as a contact insecticide against *Aphis fabae, Macrosiphoniella sanborni* and *Macrosiphum solanifolii*, the concentrate exhibited a toxicity of the same order as that of rotenone, but against *Oryzaephilus surinamensis* the toxicity was considerably less. As a stomach poison the ether extract was both toxic and repellent to *Plutella maculipennis* larvae, but was neither toxic nor repellent to *Diataraxia oleracea* larvae. Ovicidal tests against the eggs of *Plutella maculipennis* and of *Ephestia kuhniella* were inconclusive. The potency of this concentrate is therefore of a limited nature and although of roughly the same order as that of rotenone to certain aphides, it has neither the intensity of effect nor the range of insecticidal action of that compound.

PAPERS IN PRESS

140. TATTERSFIELD, F., POTTER, C., LORD, K. A., *et al. Insecticides derived from plants.* Kew Bulletin.

A number of plants, British, tropical and Chinese, have been tested for insecticidal activity.

(1) The earlier tests were all made with extracts of the ground up material, later it was found that the ground material itself could show considerable toxicity where little or none showed in an extract.

(2) When tested as extracts although some of the British plants possessed some insecticidal properties, none were of a sufficiently high standard to be worth further examination, with the possible exception of the fruits of *Euonymus europaeus*. In later tests as powder rhizomes and leaves of Winter aconite *Eranthis hyemalis* showed considerable insecticidal activity.

(3) Extracts of tropical plants showed some activity as contact and stomach poisons or as repellents but none approached in potency known plant or synthetic insecticides. When tested as powders, *Randia nilotica* (root) from Nigeria and *Randia dumetorum* from Ceylon showed considerable activity.

(4) Of the Chinese plants submitted to us, *Milletia pachycarpa* deserves most consideration as an insecticide of the Derris class although not so powerful in its toxic action as the most recent strains of *D. elliptica* root. The fact that the seed possesses insecticidal properties adds interest to this plant. The seeds should be easier to harvest than the roots. With this plant, too, notable differences in activity were found when extracts were compared with the ground up material. *Derris fordii* (root), *Tripterygium exesum* (root bark) and *Rhododendrum molle* (flowers) all showed considerable insecticidal activity as powders.

Some of the differences in effect between extracts and powders may be due to specificity but there seem to be other factors which cannot be as yet established, which we regard as important and hope to investigate.

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141. WAY, M. J., and SYNGE, A. D. 1948. *The effect of DDT and γ-BHC on bees.* Ann. Appl. Biol., **35**, 94-109.

Conclusions drawn from this work are that DDT on open blossom in the preparations used is safe to bees. There is always a danger that in a more highly activated form it may prove dangerous, since under laboratory conditions it was found to be rather more toxic as a stomach poison than Lead Arsenate. This should be remembered when the use of DDT on a large scale or on open blossom is necessary.

Field concentrations of BHC on open blossom are lethal to bees and may be harmful for at least three days after application. No repellency was noticeable and it is considered that the use of this insecticide in the field may be a serious danger to the foraging bee population. Since the speed of action is not sufficient to incapacitate contaminated workers before they return to the hive there is the further risk that nurse bees may be poisoned by contaminated pollen and nectar.

No experiments were carried out to determine the effect of BHC on honey bee larvae but preliminary work with DDT, which requires confirmation, suggests that this insecticide is not dangerous.

Certain wild bee workers have a susceptibility to both DDT and BHC comparable with that of honey bee workers but a notable resistance is shown by Bumble bee queens and drones.

142. MCINTOSH, A. H. 1947. *The relation of crystal size and shape to the contact toxicity of aqueous suspensions of DDT to* Tribolium castaneum *Hbst.* Ann Appl. Biol., **34**, 586–610.

Fairly coarse aqueous DDT suspensions can be made by the exchange of solvent method. By varying the method of preparation the mean size of crystal in suspension can be altered. The principles involved are outlined, and methods and apparatus are described for preparation of the following suspension types: colloidal DDT, a suspension containing elongated hexagonal plates, a suspension of somewhat elongated two-dimensional aggregates of plate-like crystals, and three suspensions of needle-shaped crystals of different lengths. All the DDT crystals are of the same fundamental crystal habit. These suspension types were selected to study the effect of both crystal size and shape on toxicity.

The suspensions were tested against *Tribolium castaneum* Hb. using a recently developed dipping technique. It was shown that the results obtained were independent of any operation peculiar to the technique.

Suspensions tested by a spraying method gave data similar to those obtained by dipping, except for certain anomalous results obtained where the crystals were considerably broken up in passing through the spray nozzle.

Toxicity differences were assessed by the probit method. The lines obtained for the crystalline suspensions were generally parallel to one another but the colloidal DDT gave a line differing in slope from the others.

The dipping tests showed that, within the range of crystal sizes up to about 400, toxicity increased with increasing needle length; breadth was less important but a suspension of needle-shaped crystals was as toxic as one containing considerably larger plate-shaped crystals at the same weight/volume concentration. Colloidal DDT was less toxic than any crystalline suspension. Thus, taking the median lethal concentration for $400-\mu$ needles as 100, the values for the other types were: for $120-\mu$ needles, 210; for plate aggregates $(240\times140-\mu)$, 260; for $40-\mu$ needles, 390; for $60\times15-\mu$ plates, 510; and for colloidal DDT, 1,700.

These differences in toxicity were paralleled by retention of greater amounts of DDT from the coarse suspensions than from finer ones; two extreme types were of almost identical toxicity, comparing the percentage kills produced by equal amounts of poison retained, and not by equal concentrations in suspension. The methods of carrying out these retention tests are described.

143. STOKER, R. I. 1948. *Experiments on the phytocidal properties of DDT and γ-BHC.* Ann. Appl. Biol., **35**, 110-122.

The experiments indicated that, while DDT might have deleterious effects on cucurbits, it was not otherwise seriously phytotoxic.

BHC, on the other hand, caused damage to a variety of plants. However, the concentrations used were not always necessarily those used in practice.

BHC also caused tainting of fruit and vegetables in some experiments.

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144. POTTER, C. *A modified apparatus for the estimation of the toxicity of contact poisons.* J. Econ. Ent.

An apparatus for examining the effect of contact insecticides based on that described in the Ann. Appl. Biol. (1941), **28,** No. 2, pp. 142–169, but embodying a number of modifications making for greater accuracy and ease of working is described, together with tests of its physical performance.

READY FOR PRESS

145. LORD, K. A. *The decomposition of DDT by alkaline materials.*

146. LORD, K. A. *The sorption of DDT and its analogues by chitin.*

147. LORD, K. A. *The effect of insecticides on the respiration of* Oryzaephilus surinamensis *L. An attempt to compare the speeds of action of a number of DDT analogues.*

148. LORD, K. A. *The toxicity of a number of DDT analogues and the four isomers of benzene hexachloride as contact poisons to* Macrosiphoniella sanborni *Gill. and* Oryzaephilus surinamensis *L.*

149. WAY, M. J. *Laboratory experiments on the effect of insecticides, particularly DDT and BHC, on certain aphidophagous insects and their host relationships.*

150. WAY, M. J. *A laboratory technique for the quantitative estimation of stomach poisons.*

151. WAY, M. J., and STOKER, R. I. *Experiments on the persistence of the toxicity of DDT on foliage.*

152. WAY, M. J., and STOKER, R. I. *The selection and rearing of test insects for use in laboratory studies on insecticides, particularly stomach poisons.*

WOBURN EXPERIMENTAL STATION

153. 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. Biology, **34,** 252–266.

154. MANN, H. H. 1946. *Millets in the Middle East.* Emp. J. Expt. Agric., **14,** 208–216.

155. MANN, H. H. 1947. *Pulse grain crops in the Middle East.* Emp. J. Expt. Agric., **15,** 237–259.

GENERAL

156. OGG, W. G. 1947. *Rothamsted Experimental Station.* Farming, **1,** 265.

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