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PUBLICATIONS

Physics Department

1. SCHOFIELD (R. K.). 1952. *Soil colloids*. (Chemistry and Industry, **4**, 76-78.)

The colloidal particles in soil are for the most part negatively charged, and are therefore surrounded by a Gouy layer within which the cation concentrations increase while the anion concentrations decrease towards the surfaces of the particles. Mr. A. W. Taylor has measured the ratio (activity of HCl) \div (activity of CaCl_2)^{1/2} and finds it accurately constant for a given soil when the CaCl_2 concentration is less than .01 molar. The ratio (activity of HCl) \div (activity of KCl) is constant below .03 molar KCl and the ratio (activity of HCl) \div (activity of NaCl) below .1 molar NaCl. The departure from constancy must be attributed to the penetration of chloride ions to the inside of the Gouy layer. The critical concentration for sodium is confirmed by the negative anion adsorption of bentonite.

The rate of electrophoretic migration of soil colloids reaches a limit as the electrolyte concentration in the suspending water is progressively reduced. At very low electrolyte concentrations Smoluchowski's equation is inapplicable and the so-called zeta potential calculated with its aid may be several times smaller than the actual difference of electrical potential across the Gouy layer. Using the principles underlying Gouy's theory, both this potential and the number of cations in the Gouy layer can be estimated with fair precision.

These ideas are being applied in a study which Mr. J. P. Quirk of the Australian C.S.I.R.O. Soils Division is making of the fundamental conditions leading to the deflocculation of soil colloids.

2. PENMAN (H. L.). 1951. *The rôle of vegetation in meteorology, soil mechanics and hydrology*. (Brit. J. appl. Phys., **2**, 145-151.)

Plants transpire large quantities of water at a rate primarily dependent upon weather conditions, and calculable from easily measured weather elements. They therefore play a dominant part in the water and heat balances of the earth's surface, and affect land drainage, underground storage and river flow. Calculation of the transpiration rate can be made the basis of controlled irrigation to produce maximum growth without waste of water, and it is shown that the principle can be applied equally successfully to a field, to a catchment area and to the British Isles as a whole. When the plants grow in a clay soil, shrinkage may occur as the soil dries, with damaging results on roads or buildings carried on the soil.

3. PENMAN (H. L.). 1951. *The water balance of catchment areas*. (Extrait des procès verbaux des séances de l'Assemblée Générale d'Bruxelles (20-31 Août, 1951) de l'Union Géodésique et Géophysique Internationale.) [In the press.]

Previous work has shown that natural evaporation can be estimated from weather data. For catchment areas the long-period estimate of evaporation obtained in this way should be equal to the difference between measured rainfall and run-off during the same period. A check on 40 British catchments has been successful.

For short periods the balance between rainfall, run-off and evaporation gives a measure of changes in ground storage. Calculations for two British catchments (Stour, 850 km.²; Thames, 9,900 km.²), month by month over periods of 15 and 20 years have shown good agreement with observed movements of well-level, both in long-term trends and in annual cycles. The precision obtainable is greater than that of statistical analysis, and involves the use of fewer arbitrary constants.

Chemistry Department

4. BENZIAN (Blanche). 1951. *A century-old forest nursery in Germany*. (Forestry, **24**, 36-38.)

A description of techniques.

M

5. BREMNER (J. M.) and KENTEN (R. H.). 1951. *Paper chromatography of amines*. (Biochem. J., **49**, 651-655.)

The R_F values on filter-paper chromatograms of a large number of amines in various solvents have been determined.

Ninhydrin was found to be an effective spray for the detection of primary aliphatic amines on paper chromatograms.

The results obtained suggest that amines likely to be present in biological materials could be separated and identified by paper chromatography. Relationships between the molecular structures of the amines studied and their R_F values are discussed.

6. BREMNER (J. M.). 1951. *Alkaline decomposition of amino-acids*. (Nature, **168**, 518.)

The effect of hot sodium and barium hydroxides on various amino-acids has been investigated. The results show that, under the conditions generally used for hydrolysis of proteins with alkali, threonine yields glycine and α -amino-n-butyric acid, serine yields glycine and alanine, and cysteine and cystine yield alanine.

7. CHAMBERS (W. E.) and GARDNER (H. W.). 1951. *The effect of soil calcium on the mineral content of wheat*. (J. Soil Science, **2**, 246-253.)

Samples of wheat plants were taken on five occasions throughout a season from plots treated 12 years previously with varied dressings of chalk. The pH values of the soil ranged from 4.3 to 6.5 and the yields of wheat from 3.2 to 15.8 cwt. grain per acre. Liming decreased the concentrations and total contents of manganese in the plant and increased the concentrations and total contents of magnesium, but the calcium and potassium concentrations were almost unaffected. Similar results were obtained for other crops in other years. In leys the increased calcium concentration in mixed herbage resulting from liming was due to the higher proportion of legumes and not to changes in the composition of the individual species.

8. COOKE (G. W.). 1951. *Placement of fertilizers for sugar beet*. (J. agric. Sci., **41**, 174-178.)

Ten experiments on sugar beet in 1949 tested a phosphate-potash fertilizer applied in different ways. There was no damage to germination or plant establishment by fertilizer placed in bands 2 in. to the side and 2 in. below the level of the seed.

There were no significant differences between the yields of sugar given by placed and broadcast fertilizer. Similar yields were given by broadcast applications applied early and worked deeply into the seed-bed and by dressings on the seed-bed which were worked in shallowly. Split dressings where half the fertilizer was broadcast and half was drilled beside the seed were not markedly superior to placing or broadcasting all the fertilizer. In most of the experiments placing gave more vigorous growth than broadcasting the fertilizer during late spring and early summer; at harvest this superiority had vanished.

The results of these experiments confirm those carried out in 1947 and 1948. There is no advantage from placing the full dressing of fertilizer beside the seed in districts where the crop is normally grown, except that labour is saved in applying the fertilizer.

9. COOKE (G. W.). 1951. *Fixation of phosphate during the acid extraction of soils*. (J. Soil Sci., **2**, 254-262.)

Preparations of the hydrous oxides of titanium, aluminium, and iron suspended in 0.5 N acetic acid fixed considerable amounts of added phosphate. Tests were made to prevent fixation at pH 2.5 by dissolving reagents in the acetic acid. 8-hydroxyquinoline reduced fixation by each of the three oxides, and selenious acid prevented fixation completely. Citric acid prevented fixation by ferric oxide. Citrate, oxalate, fluoride, ferrocyanide, morin, and quinalizarin all reduced fixation by alumina. Selenious acid prevented most of the phosphate fixation caused by a laterite soil at pH 2.5.

Kaolinite and halloysite fixed very small proportions of added phosphate.

at pH 2.5 and at pH 4.5. Bentonite fixed appreciable amounts of phosphate at pH 2.5. Selenious acid did not reduce fixation by any of these clay minerals.

Small amounts of the phosphate added as dicalcium phosphate and mineral phosphate were recovered when laterite soils were extracted with 0.5 N acetic acid. Satisfactory amounts of the added phosphate were recovered when selenious acid was present in the extractant.

In a series of British soils from manuring experiments on sugar beet there was very little fixation of added phosphate during extraction at pH 2.5; there was no advantage from adding selenious acid to prevent fixation. Six other selected British soils fixed considerable amounts of added phosphate at pH 2.5. Selenious acid prevented varying proportions of the fixation caused by five of the soils and had no effect on fixation by the sixth soil.

10. COOKE (G. W.). 1951. *The mechanical application of fertilizers in field experiments*. (Empire J. exp. Agric., **19**, 160-174.)

In field experiments fertilizers must be applied with greater precision than is necessary in general farm practice. Three mechanisms commonly fitted to commercial fertilizer distributors were tested in models to determine their suitability for applying experimental dressings. Tests were also made on a top-delivery drill built specially for experimental work.

Machines incorporating revolving plates or star-wheels delivered granular and powdered fertilizers uniformly in laboratory tests. A thick star-wheel delivering fertilizer mainly from the spaces between the teeth gave more constant rates than a thin wheel which delivered fertilizer both between the teeth and on the surface of the wheel. A vertical-wheel model machine delivered fertilizers very unevenly and drills incorporating such a mechanism would not be satisfactory for use in field experiments.

Granular fertilizer was generally delivered more uniformly from all machines than a powder of the same composition. Powdered fertilizer absorbed much more water from the air than granular material. All the mechanisms tested delivered dry powder more regularly than damp powder.

Irregular delivery of well-conditioned fertilizer is due to several causes. Alterations in bulk density of the material affect all conventional distributors. Where the surface of a wheel or plate is used to dispense fertilizer from the hopper, "slip" between the wheel surface and the fertilizer may be caused by high speeds or by using damp fertilizer. Gravity-feed from a hopper to a toothed wheel is likely to be unsatisfactory unless free-flowing fertilizers are used and an efficient agitator is fitted. Efficient agitation may be secured by arranging horizontal wheels so that they occupy a large part of the hopper bottom. Gravity-fed mechanisms may not deliver constant amounts of fertilizer after three-quarters of the total capacity of the hopper has been delivered. Distributors incorporating wheels having widely spaced teeth deliver different amounts of fertilizer to consecutive lengths of row since delivery is governed by the position of the teeth of the wheel in relation to the hole that allows fertilizer to fall down the delivery tube.

11. COOKE (G. W.). 1951. *Fertilizer placement machinery*. (J. Inst. Brit. agric. Engineers, **8**, 1; 7-14.)

The value of special methods of applying fertilizers for common arable crops is stated, and experiments made to determine the most satisfactory positions for placing bands of fertilizer are described. Machines built to place fertilizer in a zone near to the seed must be fitted with suitable fertilizer delivery mechanisms and coulters. The characteristics of fertilizer placement machines used on British farms are discussed.

12. COOKE (G. W.). 1951. *How to apply fertilizers for sugar beet*. (Brit. Sugar Beet Rev., **20**, 65-70.)

A review of recent experimental work comparing different methods of applying fertilizers for sugar beet.

13. CROWTHER (E. M.). 1951. *Experimental agriculture*. (Advanc. Sci., **8**, 236-248. Reprinted in Brit. agric. Bull., **4**, 200-206; summary in Nature, **168**, 232.)

Presidential address to the Agriculture Section of the British Association at the Edinburgh Meeting.

14. CROWTHER (E. M.). 1950. *Committee on nutrition problems in forest nurseries. Summary report on 1948 experiments.* (For. Comm. Rept. on For. Res., 1948-9, 60-64.)
15. CROWTHER (E. M.). 1951. *Committee on nutrition problems in forest nurseries. Summary Report on 1949 experiments.* (For. Comm. Rept. on For. Res., 1949-50, 97-105.)

Annual reports on investigations reviewed in the Rothamsted Report for 1949, 122-129.

16. CROWTHER (E. M.), WARREN (R. G.), NAGELSCHMIDT (G.) and COOKE (E. H.). 1951. *The production and agricultural value of silicophosphate fertilizers. Part V. Laboratory and Pot Culture Investigations.* (Min. Supply Perm. Records Res. and Dev., No. 11, **108**, 146-209.)

This paper and the following one summarize the agricultural side of a joint investigation by the Building Research Station and the Rothamsted Chemistry Department initiated in 1940 and continued for many years.

The Building Research Station prepared a range of high temperature phosphates or "silicophosphates" by heating phosphate rock with soda-ash and sand, giving special attention at first to materials like Rhenania phosphate with about four parts phosphate rock to one part soda-ash, and, later, to "low-soda silicophosphates" with about six parts phosphate rock to one part soda-ash.

A large number of the early burns on the 10g. scale were analysed at Rothamsted by methods adopted for speed and convenience in developmental work on production. Representative samples were compared with equal amounts of phosphorus in superphosphate and Bessemer basic slag in small scale pot experiments on radishes, using soils covering a range of pH values. The results showed that the 2 per cent citric acid method used in the United Kingdom for analysing basic slags was suitable for silicophosphates. The pot experiments showed that for a given content of citric-soluble phosphorus there were no appreciable yield differences between silicophosphate prepared with high or low proportions of soda-ash, from different kinds of phosphate rock or with varying proportions of fluorine remaining from that in the original rock. The relative values of silicophosphates, basic slags and superphosphate were similar on many kinds of soil and for many other crops. There were indications that the basic materials, silicophosphates and basic slags, were slightly more effective than superphosphate on very acid soils and somewhat less effective on neutral ones. It was confirmed for basic slags of current production that the manurial value and citric solubilities fall off regularly as the fluorine contents rise. The later large-scale productions of silicophosphate had low fluorine contents but some of the early experimental batches had relatively high fluorine contents. This did not reduce the availability of the phosphorus to plants. Whereas fluorine forms a very insoluble fluorapatite in low-soluble open-hearth basic slags, it appears to remain as a simple fluoride in silicophosphates.

17. CROWTHER (E. M.) and COOKE (G. W.). 1951. *The production and agricultural value of silicophosphate fertilizers. Part VI. Field Experiments.* (Min. Supply Perm. Record Res. and Dev., No. 11, **108**, 210-283.)

Results are presented for 130 field experiments carried out from 1941 to 1946 to assess the agricultural value of silicophosphates. In 18 experiments on swedes in 1942 high-soda and low-soda silicophosphates gave almost identical results, somewhat higher than from equivalent amounts of superphosphate. In 11 of these experiments silicocarnotite gave lower yields than the two soda-silicophosphates. In 29 experiments on swedes in 1943-6 low-soda silicophosphate was slightly inferior to superphosphate. In general, for swedes on very acid soils, silicophosphate was equivalent to superphosphate and on less acid and neutral soils inferior to superphosphate. In 38 experiments on potatoes silicophosphate gave yields similar to those from superphosphate on very acid soils, but on less acid and neutral soils silicophosphate was only two-thirds as efficient as superphosphate. In small

numbers of experiments on other crops silicophosphate was slightly better than superphosphate on sugar beet but not on oats. In experiments on permanent grass and on the establishment and growth of reseeded grass silicophosphate gave results very similar to those from Bessemer basic slag and slightly better than those from superphosphate.

18. HEINTZE (S. G.) and MANN (P. J. G.). 1951. *A study of various fractions of the manganese of neutral and alkaline organic soils.* (J. Soil Sci., **2**, 234-242.)

In a series of neutral and alkaline soils with a wide range of organic matter content the percentage of the total soil manganese extracted by neutral ammonium acetate containing 0.2 per cent hydroquinone decreased with increase in soil organic matter.

Evidence was obtained that the low values for hydroquinone-soluble manganese with the soils of high organic-matter content were due, at least in part, to retention by the soil organic matter of the divalent manganese formed by reduction.

Under the conditions used the manganese minerals hausmannite and manganite were more readily reduced by sodium hydrosulphite than by hydroquinone.

The manganese extracted from organic soils by neutral ammonium acetate containing 0.4 per cent hydrosulphite was generally greater than that if 0.2 per cent hydroquinone was used. The interpretation of these differences is complicated by the effect of hydrosulphite on the retention of divalent manganese by the soil organic matter.

Pedology Department

19. STEPHEN (I.) and MACÉWAN (D. M. C.). 1951. *Some chloritic clay minerals of unusual type.* (Clay Minerals Bull., **1**, 5, 151-162.)

In addition to the swelling chlorite previously reported (Ann. Rep. 1949) a description is given of a mineral separated from the weathering crust of an appinite, which shows a regular interleaving of swelling chlorite layers with non-swelling chlorite.

20. MUIR (A.). 1951. *Notes on the soils of Syria.* (J. Soil Sci., **2**, 163-182.)

An account is given of the main soil groups occurring in Syria together with chemical and clay mineral data. The main soil groups recognized are, in the desert, brown desert soils and solonchakous soils, with undeveloped soils corresponding in some features to the Russian sierozem and possibly to reddish chestnut soils; in the Mediterranean zone *terra rossa* and brown soils on basalt, with gley soils on alluvial flats. The effect of parent material is well marked in all the zones. The occurrence of attapulgitic in some of the desert and steppe soils is reported. Under comparable conditions well crystallized basalt gives rise to a kaolin mineral on weathering, whereas a glassy rock yields a montmorillonoid.

- 20a. BLOOMFIELD (C.). 1951. *Experiments on the mechanism of gley formation.* (J. Soil Sci., **2**, 196-211.)

Soil Microbiology Department

21. SKINNER (F. A.), JONES (P. C. T.) and MOLLISON (J. E.). 1952. *A comparison of a direct and plate counting technique for the quantitative estimation of soil micro-organisms.* (J. gen. Microbiol.) [In the press.]

Estimates of numbers of micro-organisms occurring in three differently manured soils, made by a direct counting and plating technique were compared. No correlation was found between the two methods and reasons for the large discrepancy between them are discussed. Contradictory information of the effect of external factors on soil micro-organisms can be given by the two different methods of counting.

22. NUTMAN (P. S.). 1951. *Studies on the physiology of nodule formation. III. Experiments on the excision of root-tips and nodules.* (Ann. Bot., N.S., **16**, 79-101.)

The excision of nodules and root-tips from red clover inoculated with an effective strain of nodule bacteria leads to an increase in the number of nodules subsequently formed. This is thought to be due to the removal by excision of the source of an inhibitor. In the nodule the inhibitory activity appears to be centred in the growing point and not in the bacterial tissue since the excision of the nodular meristem only will stimulate further nodulation. The response to excision depends upon the number of excisions made and is inversely related to the inherent susceptibility of the individual plant.

Excision of nodules from plants inoculated with ineffective strains of bacteria has no influence on further nodulation, presumably because the growing points of the nodules are abortive.

23. NUTMAN (P. S.) and READ (Margaret P.). *Symbiotic adaptation in local strains of red clover and nodule bacteria.* (Plant and Soil **4**, 57-75)

A study has been made of the response of local strains of British and Swedish red clover in symbiosis with nodule bacteria isolated from the localities from which the plant strains were obtained. All combinations of bacterial isolate and plant type were examined under bacteriologically controlled conditions of plant culture on an agar medium.

In the Swedish material each local strain of clover responded most effectively with bacteria isolated from its own locality. This adaptation was detected at about eight weeks from planting by scoring the seedlings for size and colour, and at harvest was reflected in a mean difference of 5 per cent on a dry weight basis. No differences were found in nitrogen content.

No adaptation was found with the British material possibly because of the more uniform climatic conditions. A small intranational adaptation was significant.

24. NUTMAN (P. S.). 1951. *Colour reactions between clay minerals and root secretions.* (Nature, **167**, 288.)

Wyoming bentonite, and to a lesser extent, fuller's earth, were observed to give a marked blue-green colour in the neighbourhood of red clover roots when incorporated into a medium in which the plants are grown. *Vicia hirsuta* under similar conditions gives an orange colour with bentonite, flax yellow and oats and a number of other species no colour. The coloured mineral taken from the neighbourhood of clover roots is sensitive to pH; at high pH it is decolourized, but on reacidifying the colour is restored. The colour is insensitive to oxidizing or reducing agents and is not readily removed by solvents. Failure to elute a coloured substance from the bentonite suggest that a chemical reaction is involved between the clay and substance secreted by the root.

25. KLECZKOWSKA (Janina). 1950. *A study of phage-resistant mutants of Rhizobium trifolii.* (J. gen. Microbiol., **4**, 298-310.)

Phage-resistant mutants were obtained from four strains of *Rhizobium trifolii*. Mutation to phage resistance tended to coincide with mutations in other features, such as morphology of colonies or effectiveness in nitrogen fixation. The accompanying mutations occurred independently, and their frequency varied widely from strain to strain.

Some mutants seemed stable in their newly acquired features; others continued to mutate at high rates.

Some of the mutants as regards nitrogen fixation were stable or could eventually be stabilized but other mutants derived from one of the parent strains remained unstable even after several successive replatings or passages through nodules.

26. KLECZKOWSKI (A.) and KLECZKOWSKI (Janina). 1951. *The ability of single phage particles to form plaques and to multiply in liquid cultures.* (J. gen. Microbiol., **5**, 346-356.)

The results of testing a bacteriophage to a strain of clover nodule bacteria using young (1 day) and old (5 days) bacterial cultures both fit to the hypo-

thesis that phage multiplication can be initiated by single phage particles. As the same phage preparations gave more plaques on solid media and higher proportions of liquid cultures in which phage multiplication could be detected, with young than with old bacterial cultures, the fit to the hypothesis is not evidence that every single phage particle will multiply. It may be so when young bacterial cultures are used, although there is no positive evidence for it. With older bacterial cultures definitely only a proportion of viable phage particles succeed in starting phage multiplication, the proportion decreasing with the increasing age of bacterial cultures used for testing.

Botany Department

27. HUMPHRIES (E. C.). 1951. *The absorption of ions by excised root systems. II. Observations on roots of barley grown in solutions deficient in phosphorus, nitrogen or potassium.* (J. exp. Bot., 2, 344-379.)

Barley plants were grown in complete culture solution and in deficiencies of phosphorus, nitrogen or potassium for a period of about six weeks. Excised roots of these plants were treated with a complete, aerated culture solution at 25°C for varying periods of time, and the changes in respiration rate, phosphorus, nitrogen, potassium, sugars and starch contents measured.

The dry weight decreased with time but the water content changes varied with treatment.

In all cases the deficient roots increased in content of the element in which they were originally deficient. The roots of the plants supplied with full nutrient usually decreased in content of phosphorus, nitrogen and potassium, but exceptions occurred and the reasons are discussed. In most of the experiments described simultaneous loss of one ion and gain of another occurred. Nitrogen-deficient roots accumulated nitrate when exposed to a complete nutrient solution, and some of this was assimilated with formation of protein. Under similar conditions nitrogen-rich roots decreased in nitrogen content and proteolysis took place.

There was a rapid fall in sucrose and reducing sugar content of the excised roots. The starch content was initially very small and showed little change with time.

The respiration rate declined with time in all treatments except where a nitrogen deficiency existed. Here the respiration rate increased to a maximum value at about eight hours and then fell. This increase in rate is attributed to protein synthesis. No evidence of a "salt respiration" was observed even when active uptake of phosphorus or potassium was occurring. In most instances the carbon dioxide evolved in respiration greatly exceeded the carbon dioxide equivalent of the sugar consumed in the same period. Exceptions were found with the nitrogen-deficient roots where less carbon dioxide was evolved than the equivalent of sugar consumed. It is probable that a part, at least, of the sugar unaccounted for was used in protein synthesis. Where the carbon dioxide of respiration was in excess of the equivalent of sugar consumed, protein or amino-acid is the most probable substrate. Respiration rate was found to be related both to nitrogen and sugar content.

Statistical examination of the data revealed that the gain or loss of an element showed a quadratic relationship with time. The rates of gain or loss of each element in each experiment was calculated at 0 hr. and 16 hr. There was a negative correlation between rate and content of element and a positive correlation between rate and sugar content. Thus for a given sugar content there was a critical concentration of element above which loss occurred and below which gain occurred. Similarly for a given content of element there was a critical sugar content below which loss, and above which gain, of element occurred. The effect of one element on uptake of another was investigated and it was concluded that in most cases the uptake of any element was virtually independent of others.

The changes in water content of the excised roots was found to be related to the rate of potassium uptake in some instances.

The conclusions to be drawn from these experiments are discussed in the light of current theories. The present results do not support the theory of "salt respiration" nor the alternative theory which postulates that active

protein synthesis is a prerequisite of salt uptake. It was found that active uptake could occur simultaneously with marked proteolysis. The uptake observed could not be explained on the basis of ion exchange.

28. HUMPHRIES (E. C.). 1952. *The absorption of ions by excised root systems. III. Observations on roots of pea plants grown in solutions deficient in phosphorus, nitrogen or potassium.* (J. exp. Bot., 3.) [In the press.]

Pea plants were grown in complete culture solution and in deficiencies of phosphorus, nitrogen or potassium for a period of about five weeks. Excised roots of these plants were treated with a complete, aerated culture solution for varying periods of time and the changes in respiration rate, phosphorus, nitrogen, potassium, sugar and starch contents measured.

There were changes in fresh weight and dry weight of the excised roots during treatment. The dry weight decreased with time but the water content changes were variable. Uptake of water was correlated with uptake of potassium and sucrose content in some instances.

There was no evidence of a "salt respiration" in those cases where active accumulation occurred.

The rates of gain or loss of phosphorus, nitrogen or potassium at 0 hr., 8 hrs. and 16 hrs., were calculated and it was found that the rate depended both on content of element in the root and the sugar content. There was very little evidence that one element affected the rate of uptake of another. Simultaneous loss of one element and gain of another occurred in some instances.

The observations appear to be best explained on the assumption that the absorbed ions are fixed in the cells in the form of loosely bound compounds and that these compounds are formed from sugars.

29. OWEN (P. C.). 1952. *The relation of germination of wheat to water potential.* (J. exp. Bot., 3.) [In the press.]

The relation of water potential to the germination of wheat was studied by supplying water to the seeds in the vapour phase, at controlled relative humidities. An apparatus for this purpose and a method of attaining the necessary precise control of temperature are described.

The critical level of water potential at which germination is completely inhibited was not reached. Even when, as a result of infection, the duration of the experiments was limited to 20 days, up to 20 per cent of the seeds germinated at a potential of -320 metres of water or a pF of 4.5. This is considerably drier than Permanent Wilting Point, which is represented by a potential of -160 metres of water, or pF 4.2. There was a marked effect of water potential on the time taken to germinate; this varied from 2 to over 20 days with variation of water potential of from zero to -320 metres. It is probable that very little further germination would have occurred after 15 days had not fungal infection enabled the seeds to obtain liquid water by bridging the air gap between seed and water source. This infection was probably responsible for the reduction in viability of the seeds at the lower potentials; the delay of germination that occurred in these conditions appeared to increase the susceptibility of the seeds to infection.

The failure of some individual seeds to germinate at potentials which allowed other seeds to germinate was not due to failure to attain a critical moisture content.

In soil, the percentage germination at low potentials was similar to that observed without soil, but the reduction in the total germinating capacity, or viability, after 20 days was not as great, and this was probably due to the reduced incidence of visible infection observed under these conditions.

30. OWEN (P. C.). 1952. *The relation of water absorption by wheat seeds to water potential.* (J. exp. Bot., 3.) [In the press.]

The relation of water absorption by wheat grains to water potential was studied by supplying water to the seeds in the vapour phase at controlled potentials.

At a potential of -250 metres of water, the curve of water uptake against time demonstrates exponential approach to equilibrium moisture content, and living and dead seeds behave similarly until germination effects are

apparent in the former. It is probable that water uptake in these early stages is due to physical, rather than physiological processes. Germination, when it occurs, causes an exponential rate of increase in the seed weight.

At higher potentials, up to zero, the uptake curves for dead seeds depart from the simple exponential relationship, and it is postulated that the total curve is made up of such an exponential curve plus a curve showing increase of rate with time to a constant rate. It is suggested that the first curve represents the physical process of imbibition by the starch, while the second represents the initiation and progress of starch hydrolysis.

A parameter a , used in the formula derived for the curves, is interpreted as representing the diffusivity of water vapour in the seed material, depending upon the physical properties and dimensions of the seed.

31. THURSTON (Joan M.). 1951. *Some experiments and field observations on the germination of wild oat (Avena fatua and A. ludoviciana) seeds in soil and the emergence of seedlings.* (Ann. appl. Biol., **38**, 812-832.)

The distinguishing characters of *Avena fatua* and *A. ludoviciana* are described.

Pot experiments and field observations showed that most seeds of *A. fatua* germinated in spring and a few in autumn; hardly any germinated in summer or winter. Seeds of *A. ludoviciana* germinated in winter only. The greatest depth of sowing from which seedlings of either species reached the surface was 9 in., but seedlings from this depth were weak and yellow when they first appeared. *A. ludoviciana* gave more and sturdier seedlings than *A. fatua* from 6 in. and 9 in. depths. There was no evidence of induced dormancy in seeds of *A. fatua* buried at depths down to 20 in. Germination of this species was hastened by monthly cultivation of the soil. The maximum survival of *A. fatua* was three years in pots and slightly longer in the field; seeds of *A. ludoviciana* in pots survived only two years. The two or three seeds of each spikelet of *A. ludoviciana* germinated in turn, starting with the largest, but the interval between germination of successive seeds varied.

Seedlings from freshly-sown seeds of both species were more vigorous than seedlings from seeds which had been buried for a year or more. Germination and subsequent growth of both species took place in soil of pH 4.5 to 7.0 approx.

32. WARINGTON (Katherine). 1951. *Some interrelationships between manganese, molybdenum and vanadium in the nutrition of soybean, flax and oats.* (Ann. appl. Biol., **38**, 624-641.)

Soybean and flax were grown in nutrient solutions containing high and low levels of molybdenum and vanadium, in combination with toxic (10-25 p.p.m.) and non-toxic (1 p.p.m.) manganese. Molybdenum (20 and to a less extent 10 p.p.m.) intensified the chlorosis induced by manganese excess, though these concentrations were harmless in the presence of 1 p.p.m. Mn. Vanadium (\equiv 1.0, 5 and 10 p.p.m. Mo) counteracted some of the symptoms of manganese toxicity, but the two higher rates were harmful to growth irrespective of the manganese supply. Toxic concentrations of vanadium at first deepened the green colour of the shoot, though apical iron-deficiency chlorosis was generally induced later. Low molybdenum (0.1 p.p.m.) or equivalent vanadium had no influence on growth or iron nutrition at either level of manganese. Visual differences were corroborated by changes in the nitrogen, phosphorus and iron contents of the plants. There was no evidence of replaceability of molybdenum by vanadium.

Oats were grown in nutrient solutions containing various combinations of manganese (nil-400 p.p.m.) and molybdenum (nil-20 p.p.m.). The appearance of manganese-deficiency symptoms was not affected by the quantity of molybdenum provided, and the manganese and molybdenum contents of the leaves were mutually independent of the quantity of each element supplied.

Statistics Department

33. BOYD (D. A.). 1951. *Economic and statistical aspects of animal and vegetable foods.* (Brit. J. Nutrition, **5**, 255-260.)

This paper formed one of a series given to a conference of the Nutrition Society on the comparative merits of animal and vegetable foods in nutrition.

The relative physiological efficiencies of the different farm animals is discussed and the paper goes on to consider how far these purely physiological measures of efficiency need to be qualified by economic considerations.

34. BOYD (D. A.). 1952. *The effect of seed rate on yield of cereals.* (Emp. J. exp. Agric.) [In the press.]

The results of all available experiments carried out in the British Isles on the effect of seed rate on the yield of cereals have been summarized, together with some data for Scandinavian countries. A substantial number of experiments were traced for winter wheat and for spring barley and oats; most of the experiments on spring oats were from the north and west of the country. The main conclusion to be drawn from the data is that the optimum seed rates (about 2 bu./acre for wheat and barley and 4-5 bu./acre for oats) are considerably below those commonly in use.

Information on the influence of other factors such as time of sowing, row spacing and nitrogen dressings was scanty. Six experiments with both seed rate and nitrogen dressings as factors suggested that nitrogen responses increased slightly as seed rate increased, but the greater response was sufficient only to balance the cost of the extra seed. The results of the Scandinavian experiments showed a definite but small increase in the percentage of lodging with higher seed rates. There was some indication that, for each cereal, lower seed rates were most successful in conditions of high fertility as judged by the level of mean yield.

There seems little need for further experiments testing seed-rates alone, except perhaps on spring wheat, but simple factorial experiments including comparisons between varieties, nitrogen dressings and perhaps sowing dates in addition to seed-rates would indicate how far the foregoing conclusions need to be modified with respect to these factors as well as for different soil types.

35. DYKE (G. V.) and PATTERSON (H. D.). 1952. *Analysis of factorial arrangements when the data are proportions.* (Biometrics.) [In the press.]

Methods of analysis of results from factorial arrangements are well known when the data are, for example, yields. In this paper a method, applicable whether the numbers of observations are equal or, as is more usual in survey work, unequal, is given for the case in which the data are proportions. The data are subjected to a transformation (here the logit transformation is suggested) such that in the new scale of measurement observations can reasonably be represented as linear functions of a number of parameters. Maximum likelihood estimates of these parameters are then found.

36. DYKE (G. V.) and SIMPSON (Emily P.). 1952. *A collaborative investigation into three methods of chemical analysis of ground Pyrethrum flowers.* (Appl. Statistics.) [In the press.]

The application of analysis of variance to an international collaborative investigation is described. Two bales of pyrethrum flowers were ground and samples of each were sent to 42 analysts in 14 countries. Duplicate determinations of pyrethrin content were made on each sample by each analyst.

The variation in the determinations by each of the analytical methods used is shown to consist of four main components; one arising from consistent differences between analysts, the second from the large difference in pyrethrin content between the bales, the third from the variation between analysts' estimates of the difference between bales, and the fourth (relatively small) from differences between the determinations made by each analyst. Increasing the number of replicate determinations made by one analyst will not provide results appreciably more consistent with those of other analysts.

The analysts were classified into two groups for each method according to their previous experience. Apparently while experienced analysts can reproduce their results with greater precision than those with little experience in the methods, the variation between analysts is greater in the case of the experienced analysts.

37. ELLISON (W.) and BOYD (D. A.). 1952. *The possibilities of marginal land reclamation: some results of a survey in England and Wales.* (J. R. agric. Soc.) [In the press.]

The results are described of a survey of marginal land in England and Wales undertaken at the request of the Agricultural Research Council in the latter part of 1949. The survey was carried out in Wales and in northern and south-western England by three independent teams of fieldmen drawn largely from members of the N.A.A.S. in the provinces concerned.

The total acreage of marginal land in private occupation is estimated at about 2.4 m. acres of which 1.0 m. acres is in Wales and the Welsh Border counties and the rest about equally divided between the northern and south-western counties of England. It is tentatively estimated that there is in addition a further 0.5 m. acres of common grazings in marginal land areas.

Visits to almost 200 farms in East Wales and northern England provided considerable information on what improvements to the land and the farmsteads are likely to be practicable, on the probable cost of these improvements and on the increased returns which they could be expected to provide.

The total capital investment required was estimated at £40-45 per acre improved, rather less than half being for improvements to the land in the form of additional cultivations, manuring, drainage and fencing, and most of the remainder for the construction of additional buildings, roads and services or for their repair or replacement.

As a result of this expenditure it is estimated that, leaving aside the acreage regarded as not worth improving, the present output per acre of marginal land could be increased by about 70 per cent above its present value. The additional annual output per 100 acres would be equivalent to about 10 two-year old store cattle or 2.3 tons of meat.

38. GRUNDY (P. M.). 1951. *The expected frequencies in a sample of an animal population in which the abundances of species are log-normally distributed. Part I.* (Biometrika, **38**, 427-434.)

In the statistical analysis of animal populations, it is of interest to study the frequency distribution of species represented in a sample by 1, 2, 3 . . . individuals. The logarithmic series has been fitted to such data with considerable success since it was put forward by R. A. Fisher, A. S. Corbet and C. B. Williams in the *Journal of Animal Ecology*, 1943; but some discrepancies have subsequently appeared in data from very large samples. The present paper discusses one of the alternative distributions which have been suggested, based on the assumption of a log-normal distribution of abundances in the population. Part I gives tables of the expected number of species in the sample and the expected number of singletons as fractions of the number of species in the population. Punched-card apparatus was used to calculate the tables. A further paper is being prepared, giving methods of calculating the rest of the distribution and of fitting it to observational data.

It has been pointed out by Dr. D. J. Finney that the function " ϕ_0 " of the present paper also gives the probability of a sterile plate in the plate-count method of estimating bacterial density, when the logarithm of the inoculum-size is normally distributed.

39. HEALY (M. J. R.). 1952. *Latin rectangle designs for 2ⁿ factorial experiments on 32 plots.* (J. agric. Sci.) [In the press.]

Designs are described for factorial experiments with 3, 4 or 5 factors at 2 levels each, using 32 plots in a 4 by 8 layout on the ground. The effects of both rows and columns can be eliminated from the estimate of error. Provided that three-factor interactions can be ignored, information can be retained on all two-factor interactions.

40. HEALY (M. J. R.). 1952. *A table of Abbot's correction.* (Ann. appl. Biol., **39**) [In the press.]

In tests of insecticides, etc., if a response of $P_0\%$ occurs in nuntreated material, an observed response of $P\%$ can be corrected to give the true response to the treatment $P'\%$ by the formula

$$P' = \frac{P - P_0}{100 - P_0} \cdot 100 - P'$$

A table is given of the correction term for values of P_0 from 1-25%.

41. PATTERSON (H. D.). 1952. *The construction of balanced designs for experiments involving sequences of treatments.* (Biometrika., 39) [In the press.]

The mathematical theory of the construction of experimental arrangements such as those which are used in change-over trials is developed. The properties of the designs and in particular requirements of balance are discussed in detail. Methods of construction are then given for designs with 3, 4, 5 and 6 periods and requiring 60 or fewer units. A number of designs outside this range are also included. There are still a number of designs which have neither been found nor proved non-existent, particularly for non-prime numbers of treatments.

42. YATES (F.). 1951. *The analysis of a rotation experiment.* (Bragantia.) [In the press.]

The paper describes the statistical analysis of a rotation experiment in which continuous maize and continuous cotton are contrasted with rotations involving cotton, maize and leguminous crops. Not all phases of each rotation were included in the experiment and the analysis is consequently considerably more complicated than would be the case in a well-planned experiment. The method followed is to fit constants by least squares, including a constant for the deterioration of the continuous cropping. The contributions of the various sources of variation to the experimental errors are also analysed.

43. YATES (F.). 1952. *Trials of coffee progenies.* (Biometrics.) [In the press.]

The arrangement of progeny trials of such plants as coffee in which vegetative reproduction is not practicable is discussed. The general problem is to select the best progenies and the best individual plants within progenies. Estimates are also required of the genetic variance within progenies for the various groups of progenies, and also of the genetic variance between progenies. This is made possible by the existence of plants from duplicated haploid homozygous lines which are similar in habit or growth and yield characteristics to the lines to be tested.

44. YATES (F.). 1951. *Sampling methods in surveys.* (Proc. Inst. Brasileiro de Geogr. e Estatística.) [In the press.]

This is an expository paper given to the Instituto Brasileiro de Geografia e Estatística.

45. YATES (F.). 1952. *Crop prediction in England.* (Proc. int. Stat. Inst.) [In the press.]

The paper gives an account of the work that has been done in recent years in England on the estimating and forecasting of the yields of agricultural crops. The subjects mainly dealt with are the estimation and forecasting of the mean yield per acre. The findings of the Survey of Maincrop Potatoes are described as well as the results of the Agricultural Meteorological Scheme involving sampling observations on the growing wheat crop. The general principles to be followed in estimation and forecasting of the yield per acre are outlined.

46. YATES (F.) and BOYD (D. A.). 1951. *The survey of fertilizer practice: an example of operational research in agriculture.* (Brit. agric. Bull., 4, 206-209.)

This paper was read at the Edinburgh meeting of the British Association and describes how during the war the need for greatly increased food production demanded that the maximum use be made of fertilizers. On the other hand, the shortages of shipping, etc., made it imperative that such supplies as were available were employed to the best advantage. This required not only a better knowledge of the responses of the various crops, but also a knowledge of the way in which farmers actually used their fertilizers. To this end a Survey of Fertilizer Practice (which is still being continued)

was instituted. The paper describes the methods and results of this survey and of the other steps that were taken to ensure a rational fertilizer policy. The whole investigation provides a good example of what is now known as operational research, and illustrates the uses and limitations of the survey technique in agriculture, and its relation to planned experimentation.

CORRESPONDENCE AND REVIEWS

47. YATES (F.) and HEALY (M. J. R.). 1951. *Statistical methods in anthropology*. (Nature, **168**, 1116.)
48. YATES (F.). 1951. Review: "Contributions to Mathematical Statistics" by R. A. Fisher. (Nature, **168**, 308-309.)
49. YATES (F.). 1951. Review: "Experimental Designs" by William G. Cochran and Gertrude M. Cox. (Sci. Progr., **39**, 353-354.)

REPORTS

50. AVIS (P. R. D.) and PRICE (C. D.). 1951. *Survey of maincrop potatoes: Northern Province*.
51. BOYD (D. A.) and DYKE (G. V.). 1951. *The place of statistics in field experiments*.
52. BOYD (D. A.) and others. 1951. *Factors influencing the yield of winter beans*.
53. CHURCH (B. M.), BLENKINSOP (A.) and others. 1951. *The Survey of Fertilizer Practice, 1950*.
54. [DAVIES (A. J.)] and LORD (Rowena). 1951. *Survey of Brassica crops in Wales*.
55. [EDWARDS (D. E.)] and BOYD (D. A.). 1951. *Results of a survey of ragwort infestation in two areas in Wales*.
56. HEALY (M. J. R.). 1951. *Statistical techniques in biology*.
57. LESSELLS (W. J.). 1951. *Investigation into the varieties of cereals grown in England and Wales, 1947-50*.
58. LESSELLS (W. J.). 1951. *A collaborative study of the analytical methods used in feeding stuffs analysis: Preliminary statistical report*.
59. SIMPSON (Emily P.) and BOYD (D. A.). 1951. *Report on a soil sampling investigation*.
60. [WILLIAMS (R.)], CHURCH (B. M.) and LORD (Rowena). 1951. *Survey of Fertilizer Practice, Cardiganshire. Report on the 1945 and 1950 surveys*.
61. YATES (F.). 1951. *The use of road traffic counts to estimate the volume of road goods traffic*. (Note prepared at the request of the Working Party of Experts on Statistical Information, Inland Transport Committee, E.C.E.)
62. YATES (F.). 1951. *Methods of "selecting" vehicles to be sampled*. (Note prepared at the request of the Working Party of Experts on Statistical Information, Inland Transport Committee, E.C.E.)

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BOOK

63. BAWDEN (F. C.). 1950. *Plant Diseases*. (Revised Edition.) Edinburgh, Nelson.

GENERAL PAPERS

64. BAWDEN (F. C.). 1951. *Growing healthier crops*. (In: Four Thousand Million Mouths, edited by F. Le Gros Clark and N. W. Pirie. Oxford Univ. Press.)
65. BAWDEN (F. C.). 1951. *The control of virus diseases*. (Proc. Int. Conf. Crop Protection.)
66. BAWDEN (F. C.). 1951. *Viruses, organisms or molecules*, (Discovery, Feb. 1951.)
67. BAWDEN (F. C.). 1952. *The interaction between virus and host cell*. (Proc. 2nd. Int. Poliomyelitis Conf.)
68. BAWDEN (F. C.) and PIRIE (N. W.). 1952. *Physiology of plant virus diseases*. (Ann. Rev. Plant Physiol.)
69. BROADBENT (L.). 1950. *In search of better potatoes*. (The Farmer (Natal), **39**, 7.)
70. BROADBENT (L.). 1951. *Lettuce mosaic in the field*. (Agriculture, **57**, 578-582.)
71. BROADBENT (L.). 1951. *Birds and rodents in relation to agriculture*. (Nature, Lond., **167**, 717-719.)
72. HULL (R.). 1951. *Report on Virus Yellows in Europe*. (Int. Inst. Sugar Beet Res., XIV Congress.)
73. HULL (R.). 1951. *Virus Yellows of sugar beet and mangolds*. (J. Inst. Corn & agric. Merchants, **3**, 25-28.)
74. HULL (R.). 1951. *Spoilage of sugar beet*. (Brit. Sugar Beet Rev., **20**, 25-29.)
75. HULL (R.). 1951. *The danger of Virus Yellows*. (Fmr. & Stk.-Breed., **65**, 87.)

RESEARCH PAPERS

76. BAWDEN (F. C.), CHAUDHURI (R. P.) and KASSANIS (B.). 1951. *Some properties of broad-bean mottle virus*. (Ann. appl. Biol. **38**, 774-784.)

A severe disease affecting many plants in a crop of broad beans was found to be caused by a previously undescribed virus, provisionally named broad-bean mottle virus. The distribution of diseased plants suggested spread by a vector, but none of the six insects tested transmitted it. The virus was transmitted to several species of leguminous plants by mechanical inoculation of sap; infectivity for some hosts seemed to be increased by propagation in these hosts.

The virus has an unusual combination of properties. Its thermal inactivation point is about 95°C, whereas sap becomes non-infective within three weeks at room temperature. The infection end-point of broad-bean sap is 1/1,000, only a little higher than the precipitation titre with specific antiserum. Precipitation with antiserum occurs over a smaller range of antigen/antibody ratios than with other viruses previously studied, possibly because of its greater solubility; it is not precipitated with (NH₄)₂SO₄ until the salt concentration exceeds 75 per cent saturation.

A specific nucleoprotein, containing nucleic acid of the ribose type, can be isolated from infective broad-bean sap in yields up to 2 g/l. Purified preparations, made by salt precipitation and ultracentrifugation, contain uniform spherical particles approximately 17 mμ in diameter. It is suggested that much of this nucleoprotein is non-infective but may otherwise resemble infective particles.

77. BAWDEN (F. C.) and KASSANIS (B.). 1951. *Serologically related strains of potato virus Y that are not mutually antagonistic in plants*. (Ann. appl. Biol., **38**, 402-410.)

Tobacco vein necrosis virus is serologically related to potato viruses Y and C. It does not protect tobacco, *Nicotiana glutinosa*, or potato plants

from infection by them, and tobacco and *N. glutinosa* plants infected with either virus Y or C are still susceptible to it. There is some evidence that it does not multiply normally in potato plants infected with virus Y and that it is sometimes suppressed in such plants.

The possession of antigenic groups in common with viruses Y and C is considered to justify tobacco vein necrosis virus as a strain of virus Y, and to be of greater taxonomic significance than failure to protect plants against other strains. A further difference from other strains is that it is more virulent towards tobacco than towards potato.

78. BAWDEN (F. C.) and KLECZKOWSKI (A.). 1952. *Ultraviolet injury to higher plants counteracted by visible light*. (Nature, Lond., **169**, 90.)

The effects of irradiating leaves of *Phaseolus vulgaris* with ultraviolet depended on whether or not the leaves were exposed to visible light immediately after irradiation. When leaves were kept in darkness, the epidermal cells collapsed and died within a few days, whereas they showed little or no ill effects when exposed to visible light. Whether illuminated or not, leaves immediately after irradiation were refractory to infection with tobacco necrosis viruses; illuminated leaves regained their original susceptibility to infection within 24 hours, whereas leaves in the dark remained highly resistant.

79. BLENCOWE (J. W.) and TINSLEY (T. W.). 1951. *The influence of density of plant population on the incidence of yellows in sugar-beet crops*. (Ann. appl. Biol., **38**, 395-401.)

The incidence of yellows virus in sugar-beet crops was reduced by increasing the density of plant population. The variations in plant population were obtained by differences in row width and singling distance. The differences in susceptibility between large- and small-topped varieties, and between early- and late-sown crops, could not be attributed solely to differences in plant size. It is suggested that close planting would increase the yields of sugar beet and reduce the losses caused by yellows virus. Roguing infected plants during the early part of the growing season did not reduce the incidence of disease.

80. BRADLEY (R. H. E.). 1952. *Studies on the aphid transmission of a strain of henbane mosaic virus*. (Ann. appl. Biol., **39**, 78-97.)

A virus causing wilt of *Datura stramonium* was identified as a strain of henbane mosaic virus. It causes necrotic local lesions in *Nicotiana rustica*, and local lesions are demonstrable in tobacco by staining with iodine. Some of the factors affecting its transmission by *Myzus persicae* (Sulz.) were studied quantitatively using these lesions.

Infective aphids differed little in their ability to cause infection, and usually produced two or three lesions. The duration of the feeding puncture did not affect the number of infections and had little effect on the percentage of aphids becoming infective. Transmissible virus did not seem to be continually imbibed while aphids fed on infected plants and there were indications that it was acquired immediately before aphids withdrew their stylets from the leaf. Aphids became infective when allowed to make feeding punctures into epidermis stripped from infected leaves.

M. persicae transmitted during feeding punctures as brief as 5 to 10 seconds; the probability of single feeding punctures resulting in infection reached a maximum with those lasting from 20 to 30 seconds during which the stylets did not penetrate as far as the centre of the epidermal cell and little or no saliva appeared to be ejected. *M. persicae* did not transmit the virus when its stylets were artificially wetted with infective sap.

Periods of darkness before inoculation with datura wilt virus increased the susceptibility of *N. rustica* to infection by rubbing, but not to infection by aphids.

81. BROADBENT (L.). 1951. *Aphid excretion*. (Proc. R. ent. Soc. Lond., **26**, 97-103.)

The excretory habits of 22 species of aphids were studied. Most species living freely on leaves or stems raised their abdomen and stayed still while

a globule of honeydew appeared ; the globule was poised on the anus for one or two seconds until flicked off by the cauda. Nymphs kicked off the globule with a back leg. Modifications of these methods by aphids living in galls and underground are described. Aphids did not excrete except when feeding ; feeding and excretion continued in darkness. Nymphs did not excrete during ecdysis, but adults continued at their usual rate when producing young. Evaporation affected the rate of excretion. It is suggested that wax and caudal development might be related to excretory habits.

82. BROADBENT (L.) and [HOLLINGS (M.)]. 1951. *The influence of heat on some aphids.* (Ann. appl. Biol., **38**, 577-581.)

The thermal death-points of five species of aphids removed from their host plants lay between 38 and 41°C, when tested for 1 hour at 60 per cent R.H. Many aphids alive after 1 hour at high temperatures died within the next day ; no *Myzus persicae* recovered and reproduced after 1 hour above 37.5°C. Third and fourth instars and adult apterae withstood heat better than first and second instars and alatae. More aphids died at 90 per cent R.H. than at 60 per cent R.H., and more at 60 per cent than at 30 per cent R.H. Aphids kept at 15 per cent R.H. for 4 hours before being heated showed a higher mortality than those kept at 95 per cent R.H. Aphids on plants withstood temperatures higher than their thermal death-point off the plant. Presumably aphids can continue to cool themselves by evaporation while feeding ; also lower temperatures on the surface of transpiring plant tissues will aid survival.

83. BROADBENT (L.), TINSLEY (T. W.), [BUDDIN (W.) and ROBERTS (E. T.)]. 1951. *The spread of lettuce mosaic in the field.* (Ann. appl. Biol., **38**, 689-706.)

The epidemiology of lettuce mosaic was studied on two farms in Buckinghamshire during 1947-50. Two patterns of spread were obvious on Farm A during 1947-8 ; (1) spread within a crop from sources initiated by seed-borne virus ; and (2) spread into a crop from nearby infected old plants. The first type caused serious losses only when aphids were unusually numerous and the incidence of seed-borne infection was high ; serious losses more often resulted from the second type. Winter crops usually suffered severely, and they initiated a cycle of infection in the spring which continued from crop to crop throughout the year when aphids were sufficiently numerous. Spread from crop to crop was much reduced during 1949-50 by planting or drilling lettuce in large blocks, well separated from each other, and by omitting a winter crop. Killing the infecting aphids with an insecticide did not prevent the introduction of virus from nearby diseased crops. The insecticidal treatment of old diseased and aphid-infested crops (but before alatae are produced) is recommended.

More diseased plants occurred near hedges, woods, trees or buildings than in the open field, presumably because such barriers halted flying aphids.

Three species of aphids were common on lettuce : *Nasonovia ribis-nigri* (Mosley), which infests the heart leaves ; and *Macrosiphum euphorbiae* (Thomas) and *Myzus persicae* (Sulzer), which infest the outer leaves. *M. euphorbiae* and *M. persicae* are vectors of lettuce mosaic, but the former is less effective than *M. persicae* which, although rarely as numerous as the other two species, is the most important vector. All three species overwintered on lettuce, and migrated from the winter crops during April-May.

One obvious need to control lettuce mosaic is the production of virus-free seed. Without this, however, the disease can be ameliorated by adopting these measures whenever practicable : lettuce crops should be planted or drilled in large blocks, well separated from each other ; diseased crops and crop-remains should be destroyed as soon as possible ; winter crops should be treated with an insecticide in late November, and insecticides should be used to prevent the production of large aphid populations, especially on old crops.

84. GLYNNE (Mary D.). 1951. *Effects of cultural treatments on wheat and on the incidence of eyespot, lodging, take-all and weeds.* *Field experiments, 1945-8.* (Ann. appl. Biol., **38**, 665-688.)

An experiment was made on the fourth, fifth and sixth successive crops of winter wheat to determine the effects of various treatments on the troubles

which result from close cereal cropping. Eyespot and lodging were prevalent in the first year (1946); weeds in the second; eyespot, lodging, take-all and weeds in the third.

Spraying with H_2SO_4 reduced the incidence of eyespot, lodging and weeds, and increased yield of grain on plots which received sulphate of ammonia (by 2.7, 2.2 and 10.0 cwt./acre in successive years).

Sulphate of ammonia increased the incidence at harvest of eyespot and lodging, reduced take-all and consistently increased yield of straw. Eyespot and lodging reduced the effect of the fertilizer on yield of grain, take-all increased it.

Increase in seed rate increased the incidence of severe eyespot and of take-all; it increased lodging except when plants were dwarfed by take-all.

Weight of straw and percentage straws with severe eyespot lesions independently affected lodging, together accounting for 51 per cent of the variance in percentage area lodged at harvest and 64 per cent of that lodged 33 days earlier.

Mean yields of grain on untreated plots sown with 3-3½ bushels seed/acre fell from 36.0 to 22.5 to 11.7 cwt./acre in successive years, whereas yields of 28.4, 29.9 and 29.1 cwt./acre were obtained on sprayed plots sown with 1½-2 bushels seed/acre which received 4 cwt./acre sulphate of ammonia showing that high yields were maintained when eyespot, lodging, take-all and weeds were controlled.

By 1948 yields of grain on unsprayed plots had fallen to the level of those on similarly manured plots on the continuous wheat experiment on Broadbalk field. Spraying increased grain by amounts similar to those resulting from one year's fallow on Broadbalk; but fallow had its greatest effects on plots with low nitrogen, spraying on those with high nitrogen.

85. GREGORY (P. H.) 1951. *The fungi of Hertfordshire*. (Trans. Hertfordsh. Nat. Hist. Soc. and Field Club. **23**, 137-208.)

A compilation of records of Hertfordshire fungi from various sources, including the records of the Hertfordshire Natural History Society & Field Club, the British Museum (Natural History), the Letchworth Museum, the Ministry of Agriculture & Fisheries Plant Pathology Laboratory, Cheshunt Experimental & Research Station and original records.

86. GREGORY (P. H.) 1951. *Deposition of air-borne Lycopodium spores on cylinders*. (Ann. appl. Biol., **38**, 357-376.)

For the study of deposition of air-borne particles on plant and trap surfaces a small wind tunnel has been constructed giving turbulent or stream-line flow up to about 10 m./sec. The efficiency with which cylinders of from 0.018 to 2.0 cm. diameter, coated with glycerine jelly, catch *Lycopodium* spores at wind speeds over the range 1-10 m./sec. has been measured experimentally with a Cascade Impactor, operated iso-kinetically, as standard. Efficiency has been found to increase as wind speed increases, and as cylinder diameter decreases. Similar effects have been observed in the field. Efficiencies observed are lower than predicted by Sell and Glauert, but agree well with those predicted by Langmuir and Blodgett, except with the narrowest cylinders. The standard vertical sticky traps used in routine trappings of fungus spores, pollen, and crop-protectant sprays and dusts have a low trapping efficiency.

87. GREGORY (P. H.) and WALLER (S.) 1951. *Cryptostroma corticale and sooty bark disease of sycamore (Acer pseudoplatanus)*. (Trans. Brit. mycol. Soc., **34**, 579-597.)

Sooty bark is a lethal disease of *Acer pseudoplatanus*. It is characterized by wilt, die-back, bark shedding and by the production of a thick layer of brownish black, dry phialosphores in the bark by a fungus invading the cambium and phloem of affected trees. It has spread continuously in and around Wanstead Park, Essex, since 1945. The fungus has been identified as the North American species *Coniosporium corticale* Ell. & Ev., which is now made the type of a new genus *Cryptostroma*, because of the characters of the stroma, conidiophores and conidia.

Conclusive evidence of pathogenicity is lacking, but there is strong circumstantial evidence that the fungus is an aggressive parasite. Prelimin-

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ary inoculation experiments suggest that the fungus is normally spread by air-borne spores entering through wounds and broken ends of branches. The fungus appears to be a new introduction into England.

88. HIRST (J. M.). 1952. *An automatic volumetric spore trap*. (Ann. appl. Biol., **39**, 251-65).

A suction trap has been made in which the spores entering a narrow orifice, directed into the wind, are impacted on a "Vaseline"-coated microscope slide moved across the orifice at 2 mm per hour. Estimates of spore content of the air can be made, with higher and less variable efficiency than by previous traps, at different times of day and thus be more closely correlated with variations in weather.

Wind tunnel tests with spores of *Lycopodium clavatum* showed maximal and minimal efficiencies of 93.8 per cent and 62.4 per cent respectively, with a suction rate of 10.0 litres per min., in the range of wind speeds from 1.5 to 9.3 metres per sec.

89. KASSANIS (B.). 1952. *Some factors affecting the transmission of leaf roll virus by aphids*. (Ann. appl. Biol., **39**, 157-67.)

Datura tatula is more suitable than potato for studying the factors influencing the transmission of potato leaf roll virus by *Myzus persicae*; it is more easily infected, provides a better source of virus for feeding aphids, produces symptoms more quickly and over a longer period of the year.

Loughnane's (1943) claim that leaf roll virus is transmitted by starved aphids that feed for only five minutes on infected plants was not confirmed. The shortest infection-feeding time in which aphids became infective was two hours; such aphids did not infect healthy plants in the first two days and, when transferred to a series of healthy plants at intervals, infected only few. The ability to cause infections was increased by increasing the length of infection feeding. Aphids fed for many days on infected plants could infect healthy plants in the first 15 minutes of test feeding, and they continued to cause infections for long periods.

Aphids became infective more readily when feeding on recently infected *D. tatula*, showing only slight symptoms, than on older plants with pronounced chlorosis; similarly, young potato sprouts showing no symptoms, were better sources of virus for aphids than older plants showing severe leaf roll.

The differences in severity of symptoms shown by potato plants with leaf roll in the field mainly occur because of differences in virulence of accompanying strains of potato virus X, but isolates of leaf roll virus were found that also varied in virulence.

90. MACFARLANE (I.). 1952. *Factors affecting the survival of Plasmodiophora brassicae Wor. in the soil and its assessment by a host test*. (Ann. appl. Biol., **39**, 239-256).

The activity of *Plasmodiophora brassicae* Wor. in the soil was measured simultaneously by counts of root hair infection on cabbage seedlings and percentage clubbing of older plants. The logarithms of the mean number of root hair infections per seedling were linearly related to the logarithms of the spore concentration in the inoculum. A high proportion of clubbed plants could be associated with very low average numbers of root hair infections on seedlings. The percentage of clubbed plants can be used for assessing quantitatively the infestation of soil by *P. brassicae* but only at lower levels of infestation than can counts of root hair infections. An effect of early application and higher levels of nutrients in increasing clubroot indicates that the nutrient status of the soil is also important, but it is not clear whether this is due to increased club growth or to a direct effect on the fungus.

Experiments on the survival of resting spores showed that, in a wet acid soil, the numbers of infections rapidly declined to a low and nearly constant level with increasing time from inoculation. This decline could be considerably delayed by alkaline or dry soil conditions or by the addition to the soil of mustard oil (allyl isothiocyanate). This fall in activity is ascribed to spontaneous germination of resting spores, germination being prevented or delayed by such conditions as alkalinity, low soil moisture or the presence of inhibitors.

In an attempt to cause biological stimulation of resting spore germination

by growing short-term catch crops in infested soil (re-infestation of the soil from diseased crucifers being prevented), there were fewer infections on test cabbage seedlings after crucifers or ryegrass had been grown than after a number of other non-crucifers. In fallow soil, a similar reduction was, however, caused by adding nutrients alone.

It was confirmed that *P. brassicae* can infect the root hairs of a number of non-crucifers and form zoosporeangia and zoospores but no other stages of the fungus have been seen in those plants.

Possible improvement of the sampling design in experiments using the root hair infection count method, is briefly discussed.

91. NIXON (H. L.) and WATSON (Marion A.). 1951. *Beet yellows virus*. (Nature, Lond., **168**, 523.)

Serological studies and electron microscopy suggest that sap from plants infected with beet yellows virus contains at least two kinds of specific particles. One of these is the rod which can be seen in electron micrographs. The other probably occurs in much higher concentration, but its size and shape are unknown.

92. WATSON (Marion A.), HULL (R.), HAMLYN (Brenda M. G.), and BLENCOWE (J. W.). 1951. *The spread of beet yellows and beet mosaic viruses in the sugar-beet root crop. I. Field observations on the virus diseases of sugar beet and their vectors Myzus persicae, Sulz., and Aphis fabae, Koch.* (Ann. appl. Biol. **38**, 743-758.)

A survey of aphids and virus diseases of sugar-beet root crops in eastern England was made between 1940 and 1948. Prior to 1943 the observations were made on fertilizer experiments; from 1943 onwards they were made on commercial fields selected for position in relation to beet and mangold seed crops. The incidence of beet yellows increased with increasing numbers of *Myzus persicae*, but not of *Aphis fabae*. The relation with *M. persicae* was sufficiently close to suggest that it is the most important, possibly the only important, vector of beet yellows virus. Beet mosaic virus also increased with increasing numbers of *M. persicae*, but the relation was not close enough to exclude the possibility of other vectors.

Numbers of *A. fabae* on sugar beet were slightly, but consistently, depressed by the use of salt as a fertilizer. Other fertilizers had variable effects. Neither aphids nor virus are likely to be greatly affected by fertilizers.

Beet yellows is most prevalent in areas where seed crops are grown, but within those areas nearness to individual seed crops did not appear to increase its incidence. *M. persicae* were more numerous on sugar beet in seed-crop areas than elsewhere, and this alone might account for the prevalence of yellows. Beet mosaic virus is more closely associated with seed crops than is beet yellows. It is most prevalent near to seed crops within the seed-crop areas.

Biochemistry Department

93. KENTEN (R. H.) and MANN (P. J. G.). 1951. *The action of peroxidase systems on ferrocyanide, molybdate, tungstate and vanadate.* (Biochem. J., **50**, 29-33.)

1. Plant peroxidase catalyses the oxidation of ferrocyanide by hydrogen peroxide. The system formed by peroxidase, together with a suitable phenolic substrate, is a much more effective catalyst of the reaction.

2. Under certain conditions the rate of oxidation of manganese by peroxidase systems is markedly increased by adding molybdates, tungstates or vanadates.

3. Evidence has been obtained that this effect is due to catalysis by peroxidase systems of the oxidation of molybdates, tungstates and vanadates to the corresponding peroxy compounds by hydrogen peroxide.

94. PIRIE (N. W.). 1951. *The clear representation of very small masses.* (Nature, Lond., **168**, 1008.)

95. PIRIE (N. W.). 1952. *Concepts out of context: the Pied Pipers of science.* (Brit. J. Philos. Sci., **2**, 269)

96. SMITHIES (W. R.). 1952. *Chemical composition of a sample of mycelium of Penicillium griseofulvum Dierckx.* (Biochem. J., **51**, 259).

97. TRACEY (M. V.). 1951. *The determination of glucosamine by alkaline decomposition.* (Biochem. J., **49**, xx.)

Glucosamine may be estimated by distillation with saturated trisodium phosphate in a Markham distillation apparatus. Ammonia is liberated quantitatively and is estimated by any suitable means in the distillate.

98. TRACEY (M. V.). 1951. *Cellulase and chitinase of earthworms.* (Nature, Lond., **167**, 77.)

Indications of the presence of cellulase in water extracts of seventeen species of British earthworms were obtained by a viscometric method. Some extracts were shown to produce reducing sugar from finely divided cellulose. Similar evidence was got for the presence of chitinase in twelve species (all those examined). Evidence indicating that some at least of the enzymes were produced by the worms is presented. Enzyme levels varied greatly within and between species.

99. HOLDEN (Margaret). 1952. *The fractionation and enzymic breakdown of some phosphorus compounds in leaf tissue.* (Biochem. J.) [In the press.]

1. The phosphorus of tobacco leaf fibre and chloroplast fractions has been fractionated into acid-soluble P, lipid P, ribonucleic acid P and deoxyribonucleic acid P. The distribution in leaves of different ages has been compared.

2. Incubation of fibre and chloroplast fractions in water and salt solutions leads to the activity of ribonuclease and a phospholipid-splitting enzyme.

3. The optimum pH for the enzymic liberation of P is between 5.5 and 6.

4. NaCl, sodium azide and sodium citrate activate the enzymic release of P.

5. Milling the fibre does not increase the rate of liberation or the total amount of P released by enzymic action.

6. Boiled fibre, acid-extracted fibre and ethanol-ether extracted fibre on incubation at pH 6 release P in organic form but no inorganic P. When incubated in the presence of dialysed sap or a fibre extract, which have ribonuclease and phosphatase activity, inorganic P is released and the total P liberated is increased.

Nematology Department

BOOKS

100. FRANKLIN (Mary T.). 1951. *The cyst-forming species of Heterodera.* (Commonwealth Agricultural Bureaux, Farnham Royal, Bucks.)

Publication of this review, which was mentioned in the Annual Report for 1949, was delayed until December, 1951. The review deals with eight species and two varieties of the genus *Heterodera* occurring in Britain, giving for each an account of the morphology, bionomics, effects on the host plant, host range, distribution and control measures as far as known up to the end of 1948. The 21 figures illustrate the morphology of the nematodes and their effects on the crops which they attack. A bibliography of 646 references covers the literature until the end of 1948.

101. GOODEY (T.). 1951. *Soil and freshwater Nematodes.* (London, Methuen & Co., Ltd.)

This work brings together information on the free-living eelworms which often occur in decaying plant tissues, soil, humus, freshwater lakes, ponds and streams. The 190 genera dealt with are arranged systematically and a description is given of the type species of each genus or of a closely related species which is illustrated by a clear text figure. In addition to morphological information, biological data, such as food habits, predatory behaviour and associations with insects, are dealt with. Nematological techniques are set out in the introductory section of the book.

METHODS

102. GOODEY (T.). 1951. *Laboratory methods for work with plant and soil nematodes*. (Min. Agric. & Fish., Tech. Bull. No. 2, H.M.S.O., 2nd ed.)

Laboratory methods and techniques are described and illustrated suitable for the collection of free-living and cyst-forming eelworms, the determination of the larval contents of cysts and the killing, fixing, processing, staining and mounting of eelworms alone or within plant tissues.

RESEARCH PAPERS

103. FENWICK (D. W.) and REID (E.). 1951. *The use of the micro-balance in laboratory experiments on Heterodera rostochiensis*. (J. Helminth, **25**, 3-4.)

Replicate batches of cysts can be put up for experiments by weight. Replacing counting by weighing involves a saving of 70-80 per cent in time. The loss of precision is very slight and data are given on it. The construction of a simple capillary balance is described.

104. FRANKLIN (Mary T.). 1952. *A disease of scabiosa caucasica caused by the nematode Aphelenchoides blastophthorus n.sp.* (Ann. appl. Biol., **39** (1), 54-60.)

A species of *Aphelenchoides* which has not previously been described has caused considerable losses by destruction of the flower buds of *Scabiosa caucasica*. The nematode is fully described and illustrated and is named *A. blastophthorus*, and an account is given of the disease caused by it.

105. GOODEY (J. Basil). 1951. *A new species of Hyphomycete attacking the stem eelworm Ditylenchus dipsaci*. (Trans. Brit. mycol. Soc., **34**, 270-272.)

Ditylenchus dipsaci found in diseased calceolaria was attacked by *Verticillium sphaerosporum* n. sp. with sticky spores adhering to the nematode cuticle. The fungus penetrated the nematodes, killed them, and produced fertile hyphae outside the host bearing phialides single or in small groups, from which bundles of spherical spores were produced on apical sterigmata.

106. GOODEY (J. Basil). 1951. *A secondary piliferous layer on the roots of Hippeastrum*. (Nature, Lond., **167**, 822-823.)

A secondary piliferous layer, growing beneath the primary one, was found on undamaged roots of *Hippeastrum*. Most of the roots had been almost destroyed by the attacks of a new species of *Rotylenchus*, which is being described elsewhere.

107. GOODEY, (T.). 1951. *Stem eelworm attack on seedlings of vetches, Vicia villosa Roth. and Vicia sativa L.* (J. Helminth., **25** (1/2), 29-32.)

Pots inoculated with the stem eelworm in dried oat straw and sown with the vetches *Vicia villosa* Roth. and *V. sativa* L. resulted in the transfer of the parasite to both. The seedlings of *V. villosa* were rather severely injured, whereas those of *V. sativa* were not so heavily attacked. The matter of the earliest records of stem eelworm attack on vetches is discussed.

108. PETERS (B. G.). 1951. *The term "Eelworm-free soil" in plant quarantine regulations*. (Nature, Lond., **167**, 368.)

109. PETERS (B. G.). 1951. *Review of work on potato root eelworm*. (Rep. Rothamst. exper. Sta., 1950, 147-156.)

Entomology Department

110. BARNES (H. F.). 1951. *Worm-eating slugs*. (Country-Side, **16**, 70-74.)

A brief illustrated account of observations, weights, feeding and marking experiments on *Testacella haliotideia* and *H. scutulium*.

111. BARNES (H. F.). 1951. *Obituary Notice—Mr. G. Fox Wilson*. (Ann. appl. Biol., **38**, 311-317.)

Contains a portrait and complete list of the publications of the late Mr. G. Fox Wilson, entomologist for many years of the Royal Horticultural Society and President 1949-50 of the Association of Applied Biologists.

112. BARNES (H. F.). 1951. *Outlines of insect phenology*. (Abst. Papers read at the Symposia, IXth Internat. Congr. Ent., Amsterdam, pp. 28-29.)

A brief abstract.

113. BARNES (H. F.). 1951. *Was it a slug or a snail?* (Bedfordshire Naturalist, **5**, 24.)

Illustrated description of molluscan feeding tracks.

114. BARNES (H.F.). 1951. *Occasional insect visitors to the home*. (Bedfordshire Naturalist, **5**, 46-47.)

Short notes on a dragon-fly, the swallow bug and a snake-fly.

115. BARNES (H. F.). 1951. *The occurrence of xylophilous gall midge larvae* (Dipt., Cecidomyiidae) *in the pantry*. (Ent. mon. Mag., **87**, 241.)

The larvae of *Xylodiplosis* sp. coming out of unseasoned wood used in pantry shelving in Co. Durham.

116. BARNES (H. F.). 1951. *Wheat midge reduces yield*. (Farmer & Stockbreeder, **65**, No. 3233, 51.)

An illustrated account of the two wheat blossom midges.

117. BARNES (H. F.). 1951. *A new gall midge* (Dipt., Cecidomyiidae) *predaceous on the flour mite*, *Tyroglyphus farinae* (Deg.). (Bull. ent. Res., **42**, 565-566.)

The description *Trisopsis tyroglyphi* Barnes from Russia.

118. BARNES (H. F.). 1952. *The gall midges of St. John's Wort* (*Hypericum spp.*) *with descriptions of two new species*. (Bull. ent. Res., **42**, 697-705.)

An illustrated account to aid workers in the field of biological control of weeds to distinguish the different species.

119. BARNES (H. F.) and STOKES (Barbara M.). 1951. *Marking and breeding Testacella slugs*. (Ann. appl. Biol., **38**, 540-545.)

An illustrated account of the activity, weights, times of activity, extent of movement and marking experiments in gardens (H.F.B.), together with the description and results of a method of keeping *Testacella* in tubes in order to study their growth rate, feeding, egg-laying and hatching (B.M.S.).

120. JOHNSON (C. G.). 1952. *The role of population level, flight periodicity and climate in the dispersal of aphids*. (IXth Internat. Ent. Congress.) [In the press.]

121. JOHNSON (C. G.) and PENMAN (H. L.). 1951. *The relationship of aphid density to altitude*. (Nature, Lond., **168**, 337.)

Log. aphid density to log. altitude as estimated by tow nets and by suction traps show on the average an approximate linear relation. The rate at which aphids return to earth can thus be estimated from a simple extrapolation of turbulence theory known to hold near the ground.

It is estimated that aphids in the lowest 2,000 ft. of the atmosphere should return to very low altitudes or to the ground during the evening in about two hours.

122. JUDENKO (E.), JOHNSON (C. G.) and TAYLOR (L. R.). 1952. *The effect of an infestation of Aphis fabae Scop. on the growth and yield of field beans, in a garden plot.* (Plant Path.) [In the press.]

The effect of a measured infestation, on total yield, stem length, number of pods, etc., was assessed. Total yield (weight of beans) was reduced by 43 per cent although the infestation was very moderate and of a degree unlikely to cause much concern.

123. WILLIAMS (C. B.). 1951. *Diversity as a measurable character of an animal or plant population.* (Année biol., 27, 129-141.)

An account is given of the new quantitative expression of Diversity that has resulted largely from work carried out at Rothamsted on the structure of animal populations. Simple methods of calculation are described and examples are given of specific and generic diversity in different types of ecological associations of both animals and plants.

124. WILLIAMS (C. B.). 1952. *Comparing the efficiency of insect traps.* (Bull. ent. Res., 42, 513-517.)

Tests were made between three different types of light traps by having each trap in a position in a small wood, and interchanging the positions each night, so that during each three days each trap had been once in each position. The sequence was repeated five times. The actual catches of Lepidoptera were converted to a logarithmic scale and an analysis of variance indicated what differences were due to differences between locations, what to difference between nights, and what to differences between the traps. It was found that the differences between the traps were not the same for all species or for all families of Lepidoptera.

125. WILLIAMS (C. B.). 1951. *Intra-generic competition as illustrated by Moreau's records of East African bird communities.* (J. Anim. Ecol., 20, 246-268.)

There has been considerable discussion for many years about the importance of intra-generic competition in determining the survival of two or more species in the same genus within a plant or animal association. This paper shows that extensive data on the species of birds inhabiting a number of different ecological areas in East Africa indicates that there are more congeneric groups than would be expected by chance, and not fewer, which would be the case if the competition with species of the same genus was more injurious to a species than any other advantages that might occur from the generic relationship.

126. WILLIAMS (C. B.). 1952. *Sequences of wet and fine days considered in relation to the logarithmic series.* (Quart. J. R. Met. Soc., 78, 91-96.)

The distribution of sequences of fine days at Rothamsted during 10 years was found to fit very closely to a logarithmic series. The sequences of wet days do not fit so closely, showing a shortage of single days and an excess of spells of two or three days over the calculated—but reasons are given showing that these differences may be accounted for.

127. WILLIAMS (C. B.). 1951. *Seasonal changes in flight direction of migrant butterflies in the British Isles.* (J. Anim. Ecol., 20, 180-190.)

There have been collected at Rothamsted, in the past 20 years, many thousands of records by field naturalists of the flight of certain butterflies, giving the date, the locality and the direction of flight. An analysis of a large number of these shows definite evidence of movements towards the north in the early summer and towards the south in the autumn in at least four species of butterflies—the Red Admiral (*Vanessa atalanta*), the Clouded Yellow (*Colias edusa*), the Pale Clouded Yellow (*Colias hyale*) and the Small Tortoiseshell (*Vanessa urticae*). In the case of the Large Cabbage-white (*Pieris brassicae*) there are two main migration seasons, at the end of May and at

the end of July, but the flights are not definitely to north and south. In this latter species most of our records are of immigrants coming in across the North Sea and the English Channel from the Continent.

128. WILLIAMS (C. B.) and SINGH (B. P.). 1951. *Effect of moonlight on insect activity*. (Nature, Lond., **167**, 853.)

Insects were trapped at Rothamsted in a "Suction Trap" which by means of an electric fan filters the small insects out of a definite volume of air in a definite time. With the trap at about five feet from the ground and working during the night from sunset to sunrise from July to November, 1950, there was a statistically significant lunar cycle, with about four times as many insects caught at new moon as at full moon.

Bee Department

129. BUTLER (C. G.). 1951. *The importance of perfume in the discovery of food by the worker honeybee* (*Apis mellifera*, L.) (Proc. roy. Soc. B., **138**, 403-413.)

Worker honeybees have an inherent tendency to associate certain perfumes with food. This results in untrained scouting bees being attracted to certain kinds of flowers, such as hawthorn and wild white clover, which they have never visited before.

If the perfume of a crop of newly-opened flowers is sufficiently powerful, it sometimes attracts scouting bees from a considerable distance away. But, normally, a bee has to approach to within a few centimetres of a mouth of a flower before she can appreciate its perfume. If a bee has learned to associate a particular perfume with a particular group of flowers she will seldom enter any flower in the group unless she can smell its perfume.

When a bee is attracted towards a flower or flower-like object and approaches it closely, any attractive perfume it may possess tends to act as a stimulus to further exploration which may involve settling on the object and possibly extending her tongue and seeking food in any small crevice in or around the object.

In general, the results obtained with untrained bees support the conclusions reached by von Frisch in 1919 in his work with trained bees, and suggest that both of these categories of bees behave in a similar way when seeking food.

130. BUTLER (C. G.). 1951. *Beekeeping and agriculture*. (Brit. agric. Bull., **4** (16), 236-241.)

A discussion of the part played by honeybees in the pollination of fruit and seed crops, and of the way in which recent advances in bee research have made it possible for beekeepers to co-operate with fruit and seed growers more effectively than in the past.

131. RIBBANDS (C. R.). 1951. *The flight range of the honeybee*. (J. Anim. Ecol., **20**, 220-226.)

The gains in weight of groups of colonies sited on the edges of crops were compared with those of groups of colonies sited $\frac{3}{8}$ and $\frac{1}{4}$ mile away from the same crops.

The chief crops chosen were apple, lime and heather; the experiments were repeated in two successive years. The effect of increased flying distance was large, and increasingly detrimental, but the magnitude of the effect varied considerably. Most of the effect was a consequence of unfavourable weather. The result illustrates a disadvantage of placing large numbers of colonies in one apiary.

132. WYKES (G. R.). 1951. *Selection of certain nectars by honeybees*. (Ann. Rep. Cent. Assoc. British Beekeepers' Assoc.)

A discussion of various factors which affect the taste perception of honeybees and their selective nectar gathering behaviour when foraging.

Insecticides and Fungicides Department

133. ELLIOTT (M.). 1951. *The insecticidal activity of the pyrethrins and related compounds*. (Pyrethrum Post, 2, 3; 18-28.)

The collected data on the relationship between the chemical structure of the pyrethrins and related compounds and their insecticidal activity are reviewed and an attempt is made to assess its significance, particularly as a guide to further work.

134. ELLIOTT (M.). 1951. *A colorimetric reaction of the pyrethrins and related esters*. (Pyrethrum Post, 2, 3; p. 24.)

Note on the possible use of the colour reaction produced with carbonyl compounds when a solution of sodium and potassium hydroxide is added to an alcoholic solution of a 2,4-dinitrophenylhydrazone. The reaction is given by the pyrethrins and related synthetic compounds and might be used in their chemical estimation.

135. LORD (K. A.) and POTTER (C.). 1951. *Studies on the mechanism of insecticidal action of organo-phosphorus compounds with particular reference to their anti-esterase activity*. (Ann. appl. Biol., 38, 495-507.)

The preparation of an extract of the mealworm larvae, *Tenebrio molitor* L. which hydrolyses ethyl butyrate and o-nitrophenyl acetate, but not acetylcholine, is described. The inhibition of this esterase by T.E.P.P.-containing materials and parathion was determined.

An enzyme that hydrolysed o-nitrophenyl acetate and was inhibited by a T.E.P.P.-containing material was demonstrated in the five other insect species used.

The relative toxicities as contact insecticides to adult *Tribolium castaneum* Hbst. of ten samples of T.E.P.P.-containing materials was compared with their relative activities as esterase inhibitors. There was not an exact quantitative correlation between T.E.P.P. content estimated chemically, insecticidal activity and anti-esterase activity; but the correlation was sufficient to suggest interdependence of these factors.

Eggs of *Diataraxia oleracea* L. and *Ephestia kühniella* Zell. were shown to contain an enzyme that hydrolysed o-nitrophenyl acetate and was inhibited by the T.E.P.P.-containing materials. This enzyme was present in eggs less than 24 hours old, i.e. before there was any visible sign of development. The T.E.P.P. was shown to be toxic to these eggs and in high concentrations kills at an early stage of development before differentiation of the nervous system. This, in conjunction with the other evidence, suggests that esterases other than the choline-esterase of the nervous system are important when considering the toxic action of these compounds.

Comparison of the anti-esterase activity and toxicity of parathion and T.E.P.P.-containing materials as insecticides showed that although the T.E.P.P. materials were the more potent enzyme inhibitors, parathion was the more potent contact insecticide to five species of insects. This appears to be due to the relative instability of T.E.P.P. The study of the rates of action of the two poisons applied at different concentrations supports this view.

136. MCINTOSH (A. H.). 1951. *Particle size of insecticidal suspensions and their contact toxicity. III. Temperature coefficients and tests by injection*. (Ann. appl. Biol., 38, 567-576.)

Aqueous D.D.T. suspensions containing particles of different sizes gave different temperature coefficients of mortality in dipping tests against adult *Oryzaephilus surinamensis* and *Tribolium castaneum*. In the range 12-30°C, colloidal D.D.T. showed a large negative coefficient, but the coefficient for a suspension of D.D.T. crystals of 400 μ was smaller (*T. castaneum*) or negligible (*O. surinamensis*). Thus, although a suspension of crystalline D.D.T. was more toxic than colloidal D.D.T. to warm insects, it was less toxic than the colloid to cool insects.

A test was made of rotenone suspensions against adult milkweed bugs (*Oncopeltus fasciatus* Dall.) by application of measured droplets under the

wings. Colloidal rotenone was more toxic than a crystalline suspension. Milkweed bugs could not be killed in this way by D.D.T. suspensions.

Tests were also made by injecting suspensions of rotenone, D.D.T. and its fluorine analogue (D.F.D.T.) into milkweed bugs. A suspension of rotenone crystals was equitoxic with colloidal rotenone against insects kept for two days at 27°C after treatment. The same was true of crystalline and colloidal D.D.T. suspensions. If the bugs were kept at 10°C, colloidal rotenone was much more toxic than crystalline rotenone two days after treatment. But if the insects were kept for about three weeks and inspected at intervals, the first apparent difference in toxicity grew smaller, and in the end it nearly disappeared. With D.D.T. the time for this to occur was about 10 days; and suspensions of colloidal and crystalline D.F.D.T. were equitoxic after only two days, even at 10°C.

In the application test, the difference between colloidal and crystalline rotenone was a real difference in toxicity. It did not disappear with the lapse of time; but in the injection tests the two forms of each poison differed only in speed of action, and not in ultimate toxicity.

137. MCINTOSH (A. H.). 1951. *Particle size of insecticidal suspensions and their contact toxicity. IV. Mechanisms of action of different size particles.* (Ann. appl. Biol., **38**, 881-898.)

Two earlier papers showed that in tests of suspensions by dipping, large crystals of D.D.T. could kill grain beetles just as efficiently as colloidal D.D.T. But with rotenone, colloidal particles were far more toxic than large crystals; this difference was partly in their speeds of action. A third paper showed that in contact action the relative toxicity of small particles is increased by cooling the beetles after treatment. In tests by injection into milkweed bugs, particle size seemed to have no effect on toxicity of rotenone and D.D.T. suspensions if the bugs were kept warm after treatment. In cool bugs, colloid acted more quickly than crystals, but the kills from the two types finally became the same. The time for this to come about was less for D.D.T. than for rotenone and less still for D.F.D.T., an analogue of D.D.T.

An explanation of these results is now given. In the action of contact poisons, attention is given to the waxy layer on the outside of the cuticle. Contact poisons must first of all dissolve in this wax layer, and it is suggested that the difference in action between rotenone and D.D.T. is due to a difference in their solubilities in wax.

Small particles will always have the advantages, over large, of greater surface area and greater ability to enter openings in the body. With *Oryzaephilus surinamensis*, a main route of entry by rotenone into the body is possibly through the spiracles, and this may be why colloidal rotenone is so much more toxic than rotenone crystals. The solubility of rotenone in wax is thought to be small and if this is so, it will be easy to saturate the wax and the higher solubility of very small particles of rotenone will be of importance. The behaviour of rotenone particles of different sizes is therefore understandable.

Entry through the body openings is evidently unimportant for D.D.T., because large crystals kill as quickly as small ones. Penetration must be through the general cuticle. It is suggested that the solubility of D.D.T. in wax is very high, compared with rotenone; the wax will not be easily saturated by D.D.T. and small particles will not have the advantage of higher solubility which is only helpful if saturation is reached.

It is shown theoretically that if solubility (in wax) does decide the relative behaviour of different-sized poison particles, then colloidal poison should be more toxic, relative to crystalline poison, if the insects are kept cool after treatment than if they are kept warm.

The following explanation is offered for the injection results. The blood of milkweed bugs contains free droplets of oil, and these are mainly responsible for carrying poison from injected crystals to the site of action. Colloidal poison probably diffuses there directly, and more quickly, in the aqueous phase of the blood. The difference in speeds of action of colloidal and crystalline poison will depend on the ratio of dose to solubility in oil. If this is large, saturation of the blood is easy, and small particles, with their special properties, act more quickly than large. If the ratio is small, the difference in speeds of action may not be detectable.

This seemed to hold for the three poisons tested, but not by any means

exactly. The ratios for rotenone, D.D.T. and D.F.D.T. were in the expected order.

Finally, it is suggested that in contact action, the relative speeds of kill of different-size poison particles may be explained in a somewhat similar way, the solubility in cuticle wax, relative to the necessary dosage, being a controlling factor.

138. POTTER (C.). 1950. *Biological methods for the assessment and study of insecticidal activity in the laboratory; their scope and validity.* (Proc. 11nd Int. Congr. Crop Protection.)

A review of methods and a discussion of the significance of the results obtained with them.

139. POTTER (C.). 1951. *Insecticides and their study.* (*The Fernhurst Lecture 1951.*) (J. R. Soc. Arts, **99**, 388-407.)

A critical review with an analysis of current problems and suggestions for further work.

140. WAY (M. J.), SMITH (Pauline) and HOPKINS (B.). 1951. *The selection and rearing of leaf eating insects for use as test subjects in the study of insecticides.* (Bull. ent. Res., **42**, 331-354.)

A number of leaf-eating insects have been studied with the object of selecting species suitable for rearing in the laboratory.

Four species have proved satisfactory for large-scale rearing throughout the year. These are *Plutella maculipennis*, *Plusia gamma*, *Diataraxia oleracea* and *Phaedon cochleariae*. A number of species possess certain disadvantages: (1) apparently obligate diapause (*Mamestra brassicae*, *Sphinx ligustri*). (2) The same as (1) with the additional disadvantage of lack of foodplant in winter (*Lymantria dispar*). (3) Uncertain copulation and oviposition (*Pieris brassicae*). When available, these species may be reared satisfactorily in large numbers.

Mesographe forficalis, *Xanthorhoe fluctuata*, *Lema melanopa* and *Crioceris asparagi* have been reared in relatively small numbers. They possess certain disadvantages but should be satisfactory for large scale rearing at any rate during some part of the year.

At present, laboratory rearing of *Phlogophora meticulosa*, *Agrotis segetum*, *Triphaena pronuba*, *Aclypea opaca* and *Athalia colibri* is considered impracticable. A number of leaf-eating species, particularly Hymenoptera, which appear to possess suitable qualities for laboratory rearing, have not yet been obtained and studied in the laboratory.

Particular attention has been paid to factors influencing development of leaf-feeding insects with the object of determining the conditions under which healthy stocks of uniform resistance can be maintained. The results of experiments on the effect of food-plant, temperature, humidity and illumination are described. Studies on the factors influencing diapause in the various species are mentioned. Descriptions are given of the rearing techniques that have been developed.

Woburn Experimental Station

141. MANN (H. H.) and BARNES (T. W.). 1951. *The competition between barley and certain weeds under controlled conditions. V. Competition with clover, considered as a weed.* (Ann. appl. Biol.) [In the press.]

Soil Survey of England and Wales

142. HEATHCOTE (W. R.). 1951. *A soil survey on warpland in Yorkshire.* (J. Soil Sci., **2**, 144-162.)

An account is given of a soil survey of the Warpland of the Humber with a description of the soils that occur and data on their chemical and mechanical composition. The technique of warping is described and the importance of subsequent drainage is shown.

143. OSMOND (D. A.). 1951. *Soil survey and soil classification.* (Sci. Hort., **10**, 160-168.)