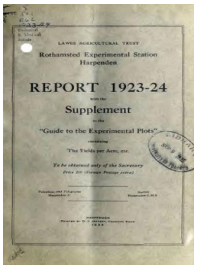
Report for 1923-1924 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



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Rothamsted Research (1925) *Summary of Papers Published 1923, 1924 - I. Scientific Papers ;* Report For 1923-1924 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 43 - 69 **- DOI: https://doi.org/10.23637/ERADOC-1-116**

SCIENTIFIC PAPERS

Published 1923 and 1924.

CROPS AND PLANT GROWTH: STATISTICAL METHODS AND RESULTS.

(Botanical, Chemical and Statistical Departments.)

(*a*) Crops and Plant Growth.

I. Winifred E. Brenchley. *"The Effect of Iodine on Soils and Plants."* Annals of Applied Biology, 1924, Vol. XI., pp. 86-111.

Attempts to find an economic use for iodine in agriculture either for partial sterilisation or as a direct means of increasing growth led in the main to negative conclusions. There was no definite evidence of partial sterilisation, nor of any reduction in loss from "damping off" of tomato seedlings as a result of treating the soil with iodine dissolved in sodium iodide solution.

Strong doses of iodine inhibited or badly checked germination of mustard. Some of the plants made a striking recovery and ultimately surpassed the untreated controls in green and dry weight. If some time elapses between treatment and sowing the mustard is unaffected, showing neither the initial toxic effect nor the later recovery and stimulation.

Barley is more easily injured than mustard by iodine.

II. Amar Nath Puri. *"Effect of Methyl and Ethyl Alcohol on the Growth of Barley Plants."* Annals of Botany, 1924. Vol. XXXVIII., pp. 745-752.

Experiments were carried out in water culture to determine the effect of various alcohols on barley when applied to the roots. Ethyl alcohol proved to be more toxic than methyl alcohol, the difference in the toxicity being not merely one of degree, but of kind. Ethyl alcohol favours the growth of ear shoots and the suppression of vegetative leaves, while methyl alcohol favours the growth of leaves and not that of the ear shoots. In the later stages of growth plants are able to withstand the toxic action of ethyl alcohol much better than earlier in life.

III. W. E. Brenchley and H. G. Thornton. *"The Relation between the Development, Structure and Functioning of the Nodules on* 'Vicia faba' *as influenced by the Presence or Absence of Boron in the Nutrient Medium."* Proceedings of the Royal Society. B. 1925.

The work deals with the growth and functioning of nodules on *Vicia faba*, comparing those grown in culture media from which boron has been excluded with those supplied with boron.

In the absence of boron the vascular supply of the nodule is defective. The strands are entirely absent, or weakly developed, running only a short distance into the nodule. The nodules having no vascular strands remain minute and are usually buried

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in the cortical tissues, and the bacteria do not swell out to form the so-called "bacteroids." In plants grown without boron, the number of nodules that attain macroscopic size is much reduced. When weakly developed strands enter the nodule, the amount of tissue containing bacteroids is closely correlated with the extent of the strands.

In the plants bearing these abnormal nodules the quantity of nitrogen fixed per nodule is small, being, in one experiment, less than one-tenth of that fixed in normal plants. The defective vascular supply is thus accompanied, on the one hand, by a reduced development of "bacteroid" forms and, on the other hand, by reduced nitrogen fixation.

In the absence or weak development of vascular strands in the nodule, the bacteria tend to become parasitic, attacking the protoplasm of the host cell. This attack is chiefly directed towards the more densely protoplasmic cells of the nodule. It is suggested that this change in the relations between the micro-organism and its host is connected with the loss or reduced supply of the carbohydrate energy material normally brought into the nodule by the vascular strands, the bacteria thus being reduced to making use of the protoplasm of the host as a source of energy.

IV. E. J. Russell. Journal of the Institute of Brewing. A full account of the work discussed on p. 17 of this report.

V. H. Lloyd Hind. "*Report on the Analyses of the Barleys of* 1922 *and of the Malts made from them.*" Journal of the Institute of Brewing, 1924. Vol. XXX., pp. 969-986.

This report gives the results of the analyses of the barleys grown under the auspices of the Institute of Brewing Barley Research Scheme in 1922, together with those of the malts made from them.

The first season's determinations were necessarily of an exploratory character, quality being a very elusive property which has not yet been reduced to exact chemical terms. The relationships between the total nitrogen and the other quantities generally estimated in malt analyses have been studied. The usual physical valuation of barley, good as it often is in the hands of experts, is shown to fail in certain conditions, some of the low valued barleys giving quite useful malts. The influence of regional conditions, soil, season, etc., on the composition of the barley and malts is shown to be greater than that of the different manurial treatments at each centre.

(*b*) Statistical Methods and Results.

Agreement of theory and observation.

VI. R. A. Fisher. "*Statistical Tests of Agreement between Observation and Hypothesis.*" Economica, 1923. Vol. III., No. 8, pp. 139-147.

In all quantitative work, both in biology and in agriculture, tests of agreement between observation and hypothesis assume

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a critical importance. Unfortunately, as early as 1900, a mathematical error was introduced into the statistical theory of goodness of fit, which has led to many inconsistencies. This error, in its application to contingency tables, was pointed out by Fisher (1922), and the method of correction was at the same time indicated. In the present paper the disputed case of the fourfold table is treated in detail. A mathematical proof of the corrected formula is given, and the experiments of Yule, designed to test this specific point, are shown to agree well with the corrected formula, while they are wholly inconsistent with the formula previously in use.

ERRORS OF OBSERVATION.

VII. R. A. Fisher. *"Note on Dr. Burnside's recent Paper on Errors of Observation."* Proceedings of the Cambridge Philosophical Society, 1923. Vol. XXI., pp. 655-658.

In small sample work, such as prevails in agricultural experimentation, the traditional methods standardised in biometry and in the theory of errors break down, so that more precise methods must be used. The first of these was developed by "Student" in 1908. In 1923 Burnside independently arrived at formulæ similar to, but not identical with, those of "Student." In the present note attention is drawn to "Student's" paper, and an exact proof is given of the accuracy of his formulæ.

THE PARTIAL CORRELATION COEFFICIENT.

VIII. R. A. Fisher. *"The Distribution of the Partial Correlation Coefficient."* Metron., 1924. Vol. III., pp. 329-332.

In 1915 Fisher gave the exact sampling distribution of the correlation coefficient, and showed that the current formula for its probable error was inadequate when applied to small samples. In the present paper it is shown that the same formula, with a simple modification, is applicable to the distribution of the partial correlation coefficient. The theoretical result so obtained is shown to be in agreement with the experimental data hitherto available.

STATISTICAL REQUIREMENTS OF ACCURATE TESTS.

IX. R. A. Fisher. *"The Conditions under which χ^2 measures the Discrepancy between Observation and Hypothesis."* Journal of the Royal Statistical Society, 1924. Vol. LXXXVII., pp. 442-450.

In making tests of goodness of fit the expectations have often, or indeed usually, to be reconstructed from the actual data with which they are to be compared. In such cases it had not been observed that it is necessary that the methods used in this reconstruction should not involve errors of fitting comparable to the errors of random sampling. In the present paper it is demonstrated that this requirement can only be fulfilled if the statistics used in the reconstruction, are not only consistent, but efficient statistics. When all statistics so employed satisfy the criterion of efficiency, it is demonstrated that the measure of discrepancy, χ^2, may, in large samples, be used with precision.

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YIELD OF BARLEY.

X. W. A. MACKENZIE. *"Studies in Crop Variation. III. An Examination of the Yield of Dressed Grain from Hoos Field."* Journal of Agricultural Science, 1924. Vol. XIV., pp. 434-460.

Records of the barley yields for 70 years have been analysed in the same manner as in the earlier study of the Broadbalk wheat results. Thirteen of the plots supply an unbroken record of manurial treatment. The variation of these is analysed into three portions representing (I) annual variations ascribable to variations in the weather; (II) steady deterioration ascribable to soil exhaustion; (III) slow changes other than steady deterioration. The annual variations are in general similar in comparable plots to those found with wheat, barley being on the whole the more variable. The average yields bring out the striking fact that no gain in yield can be ascribed to dressings of sulphate of potash, although the responses to superphosphate, rape cake and silicates (in the absence of superphosphate) are in all cases excellent. The failure of potash to improve the yield is brought out decisively by a comparison of the rates of deterioration, which seem to indicate that plots receiving potash have fallen off more rapidly than parallel plots without potash. The slow changes other than steady deterioration are smaller than on Broadbalk, and do not indicate, as on that field, any single simple explanation.

EFFECT OF MANURES ON GOUT FLY ATTACK.

XI. "MATHETES." *"Statistical Study of the Effect of Manuring on Infestation of Barley by Gout Fly."* Annals of Applied Biology, 1924. Vol. XI., pp. 220-235.

This paper is a statistical analysis of the extensive data on gout fly infestation compiled by the Entomological Department for the years 1922 and 1923. (*See* Paper XLIX.) A preliminary examination of the agreement of parallel samples showed that in the data from Woburn and from the several experiments with malting barley the infestation was homogeneous over each plot. In two of the malting barley series significant differences appeared in the infestation of different plots; the same effect was even more strongly shown at Woburn. On Hoos field (1922) the individual plots were not homogeneous in infestation, but the differences between plots were so large and so consistently related to manurial treatment as to deserve a more detailed investigation.

Of ten comparisons possible with superphosphate all indicated that this manure materially decreases gout fly infestation, even in the two cases where, in the absence of nitrogenous manuring, it has little effect upon the yield. The percentage infested, which in the absence of this manure ranged from 20 to 11, is reduced on the average by 5.1; similarly, rape cake reduced the percentage by 4.2; potassium, sodium and magnesium salts by 3.8;

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nitrate of soda by 3.4; and ammonium salts by 2.1. Silicates, although in the absence of phosphate they materially increase the yield, have no apparent effect upon gout fly infestation.

The data for 1923 were more satisfactory in that the plots this year were homogeneous. The differences in infestation associated with manurial treatment were on the whole similar to those of 1922. Phosphates, potassium, sodium and magnesium salts and rape cake again reduced infestation materially; silicates were again inoperative, but the small reduction in infestation ascribable in 1922 to nitrogenous mineral manures was absent.

RAINFALL AND WHEAT YIELDS.

XII. R. A. Fisher. *"The Influence of Rainfall on the Yield of Wheat at Rothamsted."* Philosophical Transactions of the Royal Society of London, B., 1924. Vol. 213, pp. 89-142.

This paper is the report of the methods and results of a large scale statistical reduction of the Rothamsted records of rainfall and wheat yields. The objects of the enquiry were (I) to ascertain the actual effects of varying rainfall as a factor in crop variation; (II) to discover the differential responses to rainfall of crops grown under different manurial treatments; (III) to lay a foundation both of statistical method and of ascertained fact for the agricultural evaluation of a particular season's weather, as is required for any effective system of agricultural insurance.

The greater part of the paper is devoted to the solution of mathematical problems, and the development of statistical methods, adequate to handle the type of data which it is required to treat. The procedure which emerges from the solution of these problems consists in making a detailed analysis of the weather sequence in each individual year for which crop records are available, so as to obtain measures of the several meteorological characteristics of each year. The yields are then expressed in terms of these measures in such a way that the average effect of a given weather variation upon the final crop can be calculated for all times of the year.

This procedure is applied to 65 rainfall sequences, and the average effect at all times of the year of an inch of rainfall is obtained for the 13 plots of Broadbalk wheat field which have been for the whole period under uniform treatment. Plots differently manured show very striking differences in the rainfall response, indicating that the prevailing climate is a considerable factor in determining the suitability of manurial dressings. All plots show that the rainfall of the district is on the average in excess of the requirements of wheat, but several plots indicate that more rain would be advantageous in October. All plots receiving nitrogenous fertilisers, including the 17 and 18 mineral series which receives only residual nitrogen, show a considerable loss of yield due to rain in January, which is apparently due to the loss of nitrates in drainage water. Those plots in which nitrogen deficiency is of rarest occurrence, such as the dunged

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plot and plots 10 and 11, show an even heavier loss due to rainfall in July and August.

Rainfall variations make an important contribution to the yield variation observed. In this respect rain is perhaps more important than any other single meteorological factor. It will not be possible to treat the other meteorological factors with the same precision, since the records of temperature and sunshine do not go back to the beginning of the experiments.

See also paper No. XVII.

II. METEOROLOGY.

(Physical and Statistical Departments.)

XIII. W. B. Haines. *"A Comparison of the Radiation Recorders at Rothamsted.* Journal of the Royal Meteorological Society, 1925. Vol. LI., pp. 95-100.

This paper deals with a comparison of the readings taken at Rothamsted with three types of radiation recorder. The first is a recorder of the Callendar pattern, depending upon the difference in temperature between a black and a bright resistance exposed to the sky. These readings are taken as standard. The second instrument (the Wilson Radio-integrator) reads the amount of alcohol which distils from a bulb exposed to the radiation into a similar shielded bulb. The third set of data is the record of hours of bright sunshine from the widely used Campbell-Stokes apparatus. Reference is also made to a fourth set of data, that given by an evaporimeter of the porous candle type, since the readings of this instrument are correlated to the amount of radiation.

The alcohol integrator gives readings much too low during the winter months. The readings can be fitted with fair accuracy by a formula of simple parabolic type. The possibility of introducing a temperature correction is discussed.

The hours of bright sunshine should be corrected by a factor depending upon the time of day and year (*i.e.*, upon the sun's altitude). A formula deduced by Ångstrom from the Stockholm data, for calculating total radiation from hours of bright sunshine, is examined and found fairly satisfactory for the Rothamsted data. It is concluded that such a formula, based upon the data at one station, could with due caution be adopted for another station.

The evaporimeter results follow the hours of sunshine very closely, but some care is needed in the choice of a site for this instrument.

XIV. W. D. Christmas. *"Notes on the Weather at Rothamsted."* "Nature," Oct. 27th, 1921; Jan. 16th, 1922. "The Times," Jan. 26th, July 4th, Aug. 2nd, Sept. 3rd, Oct. 1st, Nov. 2nd, Dec. 2nd, 1923; Jan. 2nd, Mar. 1st, June 2nd, Sept. 1st, 1924; Jan. 1st, 1925.

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III. THE SOIL.

(Chemical and Physical Departments.)

(*a*) MECHANICAL ANALYSIS.

XV. B. A. KEEN AND W. B. HAINES. *"On the Effect of Wear on Small Mesh Wire Sieves."* Journal of Agricultural Science, 1923. Vol. XIII., pp. 467-482.

Fine mesh wire sieves play an important part in agricultural science, especially in specifications for certain artificial fertilisers, and in mechanical analysis of soil.

The uniformity of new and worn sieves was measured with respect to the linear dimensions and area of the holes, and the diameter of the wire.

Unused sieves woven to the specification of the Institute of Mining and Metallurgy compared well, on the whole, with the specification, but in used sieves the variations were much greater: in one instance, 70 per cent. of the apertures were 25 per cent. in excess of standard area, and no less than 36 per cent. were 50 per cent. over standard. In some of the sieves the frequency distribution curves of the data showed double peaks, and the actual observation showed that there was a systematic distribution of values corresponding to these two peaks. It would appear that the guides in one of the combs through which the warp wires are led during weaving had become displaced sideways, thus giving alternate strands of wide and narrow holes.

A calculation of the increase of area of the apertures due to stretch of the sieve in use led to values below those actually observed. This discrepancy is due to the wires becoming displaced from their original positions under the rubbing action employed in mechanical analysis.

Of the two systems of weaving—double and single—the former is stronger, but the latter is more uniform, since the warp and weft grip one another more tightly and more often in a given area. The fact that it is intrinsically neither as strong nor as durable as a double weave is an advantage, as with ordinary use, some of the strands break and the sieve is discarded before any very serious alteration in aperture area has arisen.

XVI. J. R. H. COUTTS, E. M. CROWTHER, B. A. KEEN, AND S. ODEN. *"An Automatic and Continuous Recording Balance. (The Odén-Keen Balance.)"* Proceedings of the Royal Society. A., 1924. Vol. CVI., pp. 33-51.

In connection with (*a*) the newer methods of mechanical analysis which involve only a single sedimentation, and (*b*) further experiments on the evaporation of water from soil, there arose an urgent necessity for some form of automatic self-recording balance. At the request of Prof. Sven Odén, of Stockholm, the Soil Physics Department has devised an improved form of his original type of recording balance. The control is effected electromagnetically. The current passing through a solenoid is automatically adjusted, so that the force of attraction on a magnet

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suspended from one pan of an analytical balance is just sufficient to keep the balance in equilibrium. The adjustment of this current is effected by the movement of a sliding contact along slide wires, and this movement is in its turn controlled by the slight swing of the pointer attached to the balance beam, as the latter moves from its equilibrium position. When the current —and hence the weight on the second pan of the balance— reaches a pre-arranged value, a subsidiary circuit is automatically closed, and a small phosphor-bronze ball of known weight is deposited on the pan above the magnet, the sliding contact is drawn back to its initial position, and the cycle of operations recommences.

The arrangement of the circuits is such that the distance of the sliding contact from its zero position is to a close approximation linearly related to the current, and hence a recording-ammeter is not needed, as a record on a rotating drum of the slider position is sufficient to give the required data. The records consist of a series of stepped curves and a very open scale is obtained.

The apparatus can be used with no loss of sensitivity up to the maximum load the balance is designed to carry. Further, the sensitivity can be very simply adjusted, so that both rapid and slow changes of weight can be recorded.

The apparatus can be employed with advantage in experiments involving a continuous measurement of increasing or decreasing weight, and its application to the study of sedimentation and flocculation of soil particles, and the evaporation of water from fibres is illustrated in the present paper.

The earlier work was carried out with the assistance of the Cambridge Instrument Company, 45, Grosvenor Place, London, and the completed form of the instrument has been placed by them on the market.

XVI. (*a*). B. A. Keen. "*The Odén-Keen Automatic Balance.*" Proceedings of the Fourth International Conference on Soil Science. Int. Inst. of Agric., Rome, 1924.

(See preceding paper for abstract.)

XVII. R. A. Fisher and Sven Oden. "*The Theory of the Mechanical Analysis of Sediments by Means of the Automatic Balance.*" Proceedings of the Royal Society of Edinburgh, 1924. Vol. XLIV., pp. 98-115.

Ideally the mechanical analysis of a soil should enable us to state what fraction of the soil consists of particles smaller than any assigned size. In 1916 Odén showed that the distribution by size of the particles could be obtained by a sedimentation process. The necessary sedimentation curve may most readily be obtained by means of the Odén-Keen automatic balance. (*See* paper XVI.) The present paper consists of :—

(*i*) A simplified mathematical statement of the theory of the changes taking place in the fluid during sedimentation, showing

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from what physical observations the required distribution curve may be derived, and verifying Odén's formula.

(*ii*) A criticism of Schloesing's sedimentation formula.

(*iii*) The development of practical methods for the statistical treatment of the readings of the automatic balance in order to derive the required curve of size distribution.

(*iv*) An examination of the degree of accuracy obtained in a duplicate experiment carried out on Rothamsted soil, by the Physical Department; and of the incidence of random and systematic errors in this experiment.

(*v*) A discussion of the causes of error in the current technique, and of the means of control of the fluid motions to which they appear to be due.

(*b*) PHYSICAL PROPERTIES OF SOIL.

XVIII. B. A. KEEN. *"Recent Advances in Soil Physics."* Proceedings of the Fourth International Conference on Soil Science. (Int. Inst. of Agric., Rome, 1924.)

A review of work in this subject since 1900, and a critical discussion of some outstanding problems.

XIX. E. M. CROWTHER and J. R. H. COUTTS. *"A Discontinuity in the Dehydration of Certain Salt Hydrates."* Proceedings of the Royal Society. A., 1924. Vol. CVI., pp. 215-222.

During a preliminary study of the evaporation of water from soils and colloidal material, experiments were made with the simplest solid systems, viz., crystalline hydrates, using the automatic balance (paper XVI). In the evaporation of water from $CuSO_4.5H_2O$ and $BaCl_2.2H_2O$ at 100°C, a marked discontinuity was noticed. The evaporation proceeded rapidly up to the formation of the definite hydrates $CuSO_4.3H_2O$ and $BaCl_2.1H_2O$, but was almost completely interrupted at these points. After varying periods the evaporation recommenced and proceeded rapidly to the formation of $CuSO_4.1H_2O$ and $BaCl_2$. A tentative explanation is advanced, based on Langmuir's treatment of actions at surfaces.

XX. B. A. KEEN. *"On the Moisture Relationships in an Ideal Soil."* Journal of Agricultural Science, 1924. Vol. XIV., pp. 170-177.

This paper consists of a critical examination of a portion of Wilsdon's theoretical investigation on moisture relationships. Wilsdon's investigations appeared to show that the maximum moisture holding capacity of an ideal soil (*i.e.*, one built up of uniformly packed solid spheres all having the same radius) was 23.46 per cent. Further, his experimental and theoretical work indicated that the total amounts of water held by the soil colloids, as distinct from the "free" or interstitial water was 4.7 x (Hygroscopic Coefficient). The total moisture holding capacity of an ordinary soil would therefore be :—4.7 x (Hygroscopic Coefficient) + 23.46, which is remarkably close to Briggs' well

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known empirical expression :—4.3 x (Hygroscopic Coefficient) +21. The present paper shows that the derivation of the value 23.46 per cent. cannot be substantiated, because the analyses take no account of the fact that the adjacent water wedges surrounding each point of contact of the spheres come into contact with each other at a moisture content very considerably below 23.46 per cent. The value is in fact much too high, and Briggs' figure 21 still remains empirical. An explanation is suggested for the gradual decrease with height in the moisture content of a long unbroken soil column saturated at the base.

XXI. E. M. Crowther and A. N. Puri. *"The Indirect Measurement of the Aqueous Vapour-pressure of Capillary Systems by the Freezing-point Depression of Benzene."* Proceedings of the Royal Society. A., 1924. Vol. CVI., pp. 232-242.

With a view to developing a technique for the measurement of vapour pressures in relatively dry soil, a study was made of the freezing-point depressions (F.P.D.) of moist benzene in equilibrium with the soil. Sidgwick's assumed proportionality between the F.P.D. of benzene and the aqueous vapour pressure of the with the soil. Sidgwick's assumed proportionality between the F.P.D. of benzene and the aqueous vapour pressure of the material with which it is in equilibrium, was substantiated by experiments on sulphuric acid-water mixtures. All soils showed a systematic deviation, the observed F.P.D. being in all cases greater than that calculated from the vapour pressure. By postulating a system of micropores or capillaries in the soil, and allowing for the effect of benzene on the surface tension of the soil water, an expression was obtained which agreed with the observed values. This agreement supports the view that many of the observed colloidal properties of soils can be interpreted in terms of minute capillaries.

XXII. A. N. Puri, E. M. Crowther and B. A. Keen. *"The Relation between the Vapour Pressure and Water Content of Soils."* Journal of Agricultural Science, 1925. Vol. XV., pp. 68-88.

Much of the modern work on the physical properties of soils has been interpreted on a colloidal basis. There is evidence that the colloidal portion can be regarded as possessing a reticulate structure, possibly analogous to that shown to exist in silica gels. These minute pores largely control the vapour pressure of soils at different moisture contents, and a measurement of this property offers a promising line of attack on the physical relations between the colloidal soil material and water.

Three experimental methods were tried and the most convenient was one in which the soils were allowed to come into equilibrium in a vacuum dessicator, over sulphuric acid of the desired strength. Some of the soils were subjected to various treatments known to affect other physical properties, such as successive wetting and drying, heating, and addition of salts. The general results were as follows :—The water absorption at

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definite relative humidities is almost independent of temperature over the range 20° to 40° for high relative humidities, but decreases markedly with increasing temperatures for the lower relative humidities. This influence of temperature on the relative vapour pressures of moist soils is connected with the fact that dry soils liberate heat when wetted. All soils show considerable hysteresis in their vapour pressure relationships. The apparent water content or loss on heating of a soil increases regularly with the temperature of heating up to about 200°C. Soils heated to various temperatures between 100° and 200° C. show substantially the same water absorptions at different relative humidities. The water absorption by a soil is markedly affected by previous treatment with agents known to disintegrate the soil.

The vapour pressure curves of the various soil fractions, including clay, differ only slightly in type from that of the soil, although the absolute amounts of water taken up increase with the increasing specific surfaces.

Some preliminary data are given to show the complicated effects resulting from addition of salts to the soil.

XXIII. A. N. Puri and B. A. Keen. "*The Dispersion of Soil in Water under Various Conditions.*" Journal of Agricultural Science, 1925. Vol. XV., pp. 147-161.

A study has been made of the intensity of the forces binding soil particles together, when the soil has been previously subjected to treatments simulating various field conditions, and certain laboratory processes connected with physical, chemical and biological investigations.

The technique consisted in shaking soil with water under reproducible conditions, allowing the mixture to stand for 24 hours, and then determining the concentration of soil in the top 8.5 cms. of the suspension : this was expressed as a percentage of the original concentration, and the value thus obtained was called the dispersion factor of the soil under the conditions of treatment.

The following conclusions emerge from the data :—

(*a*) Disintegration of soil aggregates by shaking in water proceeds continuously, rapidly at first and then more slowly. After nearly 100 hours of shaking, the dispersion factor is still slowly increasing, and its change with time after completion of the first rapid increase can be expressed by the equation :—

$$d = a + K \log t.$$

where d = disperson factor, t = time of shaking, a and K = constants

(*b*) The dispersion factor depends on the original concentration of the soil. There are slight but systematic changes in the lower concentrations and flocculation occurs when a certain maximum concentration is passed. It is probable that, besides the increase in concentration, the concomitant increase in the amount of soluble salts present is concerned in the flocculation process.

(*c*) The dispersion factor for clay decreases continuously with decrease in initial moisture content, whereas with soil a stationary value is reached when the moisture content is reduced to a certain

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value. Contact with water or water vapour breaks up soil aggregates only very slowly.

(*d*) A progressive decrease in the dispersion factor is caused by heating the soil to temperatures over 110° C., but up to this temperature no reduction appears. In the case of clay, heating to 100° C. greatly reduces the dispersion factor.

(*e*) The influence of electrolytes is progressive and gradual, and not a sharp flocculation or deflocculation. With successive increases in concentration of good deflocculants the dispersion factor increases to a maximum, then decreases slowly, and then rapidly until complete flocculation occurs.

(*f*) A comparison of various methods recommended for soil dispersion shows that the use of a rubber pestle is one of the most efficient means.

XXIV. A. N. Puri. *"A Critical Study of the Hygroscopic Coefficient of Soil."* Journal of Agricultural Science, 1925. Vol. XV., pp. 272-283.

The Hygroscopic Coefficient, defined as the percentage by weight of water held by a soil when in equilibrium with an atmosphere saturated with water vapour, has been much used, especially in America, as a means of characterising a soil. Accurate determination of the value is not easy, owing, among other things, to the difficulty of maintaining a correctly saturated atmosphere. The present investigations were made with a technique deliberately refined beyond that possible in routine laboratory determinations, in order to obtain some idea as to the inherent value of the method itself, and of the justification of the conception of the Hygroscopic Coefficient.

The results, while incidentally clearing up the controversy whether the Hygroscopic Coefficient, as determined under ordinary conditions, increases or decreases with increase of temperature, show definitely that even with a very careful technique, only qualitative accuracy can be obtained. The paper concludes with a short discussion of the manner in which soil absorbs water vapour, in which the conception of the Hygroscopic Coefficient is criticised on physical grounds.

XXV. W. B. Haines. *"Studies in the Physical Properties of Soils. I. Mechanical Properties Concerned in Cultivation."* Journal of Agricultural Science, 1925. Vol. XV., pp. 178-200.

The general problem considered in this paper is that of supplying, by means of laboratory tests, data as to the mechanical behaviour of soils sufficient to form a basis for the mathematical treatment of ploughing and cultivation operations in the same way that other engineering problems are usually treated. As a first step to this end certain physical investigations already carried out at Rothamsted have been grouped together under the following heads :—

(*a*) Soil cohesion.
(*b*) Soil plasticity.
(*c*) Friction between a metal surface and soil.

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In each case the variation of properties for different soil types is considered, as well as the variation in the same soil for different moisture contents.

(*a*) *Cohesion.* Atterberg's method was used, the apparatus being specially designed to give the cutting or breaking strain of prepared soil specimens. A comparison of the author's results with Atterberg's shows a difference in character of theoretical importance.

(*b*) *Plasticity.* A simple statement of the constants involved in measurements of plasticity is first made, in order to clear a certain confusion hitherto shown in applying the subject to soils. One of these constants, which may be called " the pressure of fluidity," was measured by a new method which has proved a sensitive means of classifying the behaviour of clays.

(*c*) *Surface Friction.* The apparatus used for friction measurements is described in another communication (*see* paper No. XXVI.). The results show very marked differences according to soil type, and throw an interesting light upon the theory of soil moisture relationships. The subject is a new one in soil measurements, and the method promises to be very effective in the physical examination of soils.

Although much remains to be done to fill in gaps in the data, the grouping together in this way has thrown into clearer relief many of the outstanding problems of soil physics.

(*c*) SOIL CULTIVATION.

XXVI. E. M. CROWTHER and W. B. HAINES. *" An Electrical Method for the Reduction of Draught in Ploughing."* Journal of Agricultural Science, 1924. Vol. XIV., pp. 221-231.

The frictional force between mouldboard and the soil constitutes an appreciable fraction of the total draught in ploughing. In this paper a simple electrical method is suggested and investigated for the reduction of friction on moist substances. In its application to ploughing, a current is passed through the soil having the mouldboard as the negative electrode. As moist soil exhibits the phenomenon of electro-endosmosis, and as the soil colloids have a negative charge, water moves through the moist soil towards the negative electrode under the action of the electric current. The mouldboard thus becomes covered with a water film, which should act as a lubricant and reduce the ploughing draught. Under laboratory conditions, striking reductions in friction were obtained. A number of field experiments showed that the device reduced the effort required in ploughing. The reduction was, however, much smaller than in the laboratory experiments, but there is considerable possibility of improvement in the method of applying the current, and thus obtaining greater reduction in draught. The method promises to have useful extensions to certain other cultivation processes such as mole drainage and deep ploughing. (*See* paper LXI.)

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(*d*) SOIL REACTION.

XXVII. E. M. CROWTHER. *"Studies in Soil Reaction. III. The Determination of the Hydrogen Ion Concentration of Soil Suspensions by Means of the Hydrogen Electrode."* Journal of Agricultural Science, 1925. Vol. XV., pp. 201-221.

An improved hydrogen electrode apparatus is described and its use illustrated by reference to a number of soils showing characteristic crop failures. The buffer action of soils is represented by titration curves giving the equilibrium pH values corresponding to additions of varied amounts of lime water. Adjacent or similar soils may show considerable differences in pH value with no change in their buffer action. In such cases any "lime requirement" method is likely to show results which are correlated with the pH values, but this cannot be the case in soils of different types with different degrees of buffer action. Additions of neutral salts cause considerable increases in the hydrogen ion concentrations of both acid and slightly alkaline soils. Sodium salts, including sodium hydroxide, always give lower hydrogen ion concentrations than the corresponding potassium or calcium salts. The titration curves of a soil in the presence of different amounts of a neutral salt run parallel; the buffer action of a soil is not affected by neutral salts. Extraction of a soil with water causes a considerable reduction in the hydrogen ion concentration, *i.e.*, an increase in pH value. This effect may operate in wet seasons in diminishing the infertility of acid soils and in increasing the stickiness of heavy soils. A number of soils showed a regular decrease of 0.1 in pH value for a two-fold increase in the soil-water ratio. This "dilution effect" and the "salt effect" appear to result from a complex equilibrium between the hydrogen ions and metallic cations, at the soil surface, and form important cases of "base exchange." The indicator methyl red gives erroneous results in turbid suspensions owing to the absorption by the soil of the red form, which is apparently a cation exhibiting "base exchange" with the soil.

XXVIII. E. M. CROWTHER. *"Studies in Soil Reaction. IV. The Soil Reaction of Continuously Manured Plots at Rothamsted and Woburn."* Journal of Agricultural Science, 1925. Vol. XV., pp. 222-231.

The continuously manured grass plots at Rothamsted and barley plots at Woburn are acid, except in one or two cases. Sulphate of ammonia has caused a marked increase in acidity, and nitrate of soda a slight increase. The farmyard manure plot at Woburn is appreciably less acid than the unmanured. Mineral manures have had little or no effect on the reaction of the surface soil, but sulphate of potash has slightly increased the acidity of the subsoil below the more acid plots. There is some evidence that the acidity of the surface soil at Rothamsted is approximating to an upper limit of pH value 3.8, where large dressings of sulphate of ammonia are applied. The change in

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pH value as a result of liming is less than that shown in the laboratory, owing in part to the reduction of the acidity of the subsoil. Application of amounts of lime equivalent to the Hutchinson-MacLennan " lime requirement " reduced the acidity by an amount equal to +0.5 to +0.7 in pH value, but the soils still remained appreciably acid.

XXIX. E. M. CROWTHER. *" Studies in Soil Reaction. V. The Depth-distribution of Reaction and Flocculation in Continuously Manured Soils."* Journal of Agricultural Science, 1925. Vol. XV., pp. 232-236.

The reactions of the unmanured and the limed and unlimed portions of the sulphate of ammonia plots on Rothamsted Park Grass and Woburn Barley plots change steadily with increasing depth, and at 36in. still show the same relations as in the surface soil. The difference in pH values between the limed and unlimed portions is substantially constant at all depths down to 36in. The reaction of the subsoil plays an important part in determining the effect of liming. The subsoils from the sulphate of ammonia plots at both centres are highly flocculated. Mixtures of 1 part of soil with 5 parts of water exhibit complete flocculation in the case of all samples below 9in. and the velocity of sedimentation decreases and the volume of the final sediment increases regularly and markedly with the depth. Such changes in soil texture possibly constitute an important factor in the effects due to a high surface acidity.

XXX. E. M. CROWTHER and W. S. MARTIN. *" Studies in Soil Reaction. VI. The Interaction of Acid Soils, Calcium Carbonate and Water, in Relation to the Determination of 'Lime Requirements.' "* Journal of Agricultural Science, 1925. Vol. XV., pp. 237-255.

The Hutchinson-MacLennan " lime requirement " method has given useful results in the hands of certain workers but not of all. The variations in " lime requirement " resulting from changes in the amounts of soil and calcium bicarbonate are shown to be connected with buffer action of the soil, as determined by electrometric measurements of the hydrogen ion concentration, after the addition of lime water. A systematic difference between the direct electrometric titration curves and the indirect titration curves calculated from the calcium bicarbonate experiments, is due to the variable calcium concentration of the bicarbonate solutions. In the presence of calcium chloride both methods show higher acidities for a given base absorption, and give almost identical titration curves. The Hutchinson-MacLennan " lime requirement " is always less than that equivalent to the amount of lime required to give a neutral solution (pH=7.0) in the electrometric titrations, a result which accords with the field results quoted in the preceding papers. The calcium bicarbonate solutions after treatment with soil are quite acid, with pH values always less than 6.2, but the salt effect tends to give higher base absorption than is given for the same pH value in the titration Curves. Better values for the " lime requirement " are obtained by interpolating the results to a constant,

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but arbitrary, calcium bicarbonate concentration. An empirical relationship has been found which enables such an interpolation to be made from a single experiment. The Hutchinson-MacLennan method can give no indication of the intensity of soil acidity, but it will serve a useful purpose in showing the amount of lime needed to reduce this acidity considerably; it gives guidance as to the amount of lime to apply, where pH measurements and other tests and observations have shown that lime is needed. The interaction of soil with calcium acetate and dicalcium phosphate give results of the same type as those given with calcium bicarbonate. Calcium carbonate suspensions, containing phenol red or cresol red, show an almost instantaneous colour change when poured on air-dry acid soil, owing to the decomposition of some calcium carbonate. The interaction of acid soil with calcium carbonate and water in full bottles liberates an amount of total acid, as carbonic acid and calcium bicarbonate, which is greater than that estimated by the Hutchinson-MacLennan method. Still greater quantities of acid are liberated when water is percolated through intimate mixtures of acid soil and calcium bicarbonate. These differences are to be explained by the higher pH values of the liquid at equilibrium, and the conditions approximate more closely to those obtaining in the field. (*See* paper LXII.)

See also Paper LVI.

XXXI. T. Eden. *"The Edaphic Factors Accompanying the Succession after Burning on Harpenden Common."* Journal of Ecology, 1924. Vol. XII., pp. 267-286.

The floristic survey of Harpenden Common shows the succession of vegetation after the periodical fires to be *Rumex acetosella, Holcus lanatus, Agrostis.* Of the soil factors influenced by burning those of soil reaction (in terms of the Hutchinson-MacLennan Lime Requirement and pH measurement) and humus content show a gradation accompanying the progress of the succession. The nature of the acidity and its probable relation to the succession, the formation of humus and to burning are discussed.

(*e*) CHEMICAL PROPERTIES OF SOIL.

XXXII. H. J. Page and W. Williams. *"Studies on Base Exchange in Rothamsted Soils,"* Transctions of the Faraday Society, 1925. Vol. XX., pp. 573-585.

The content of exchangeable bases in the soil of certain plots on Broadbalk field, and the Grass Plots, Rothamsted, has been determined by Hissink's method. The results show that in the soil of Broadbalk field, containing excess of chalk :—

(*a*) The relative proportions of the different bases vary consistently with the manuring. In all the soils about 90 per cent. of the exchangeable bases (in equivalents) consists of calcium.

(*b*) The total content of exchangeable bases can be correlated with the amount of fine inorganic material (diameter of particles less than 0.005 mm.) and of organic matter.

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(*c*) There is probably a gradual conversion of exchangeable potash to a non-exchangeable form, or *vice versa*, depending on whether potash manures are used or not.

In the acid soil of the Grass Plots, from which chalk is absent, the soils are all unsaturated, and the amount of exchangeable calcium can be correlated with the pH of the soil.

The bearing of these results on current theories of base exchange in soils, and on the relation between soil acidity and ionic exchange, is discussed.

XXXIII. N. N. Sen Gupta. *"Dephenolisation in Soil, Part II."* Journal of Agricultural Science, 1925.

Soils possess the power of destroying phenol under conditions precluding the possibility of biological action. This power, which is greatly increased by preliminary acid-treatment of the soil, varies greatly from soil to soil. It is shown that this chemical dephenolising power of soils depends upon the presence of an oxidising agent, and that most of the action is due to the presence of manganese in the soil, probably in the form of manganese dioxide.

(*f*) CHEMICAL ANALYSIS.

XXXIV. T. Eden. *"A Note on the Colorimetric Estimation of Humic Matter in Mineral Soils."* Journal of Agricultural Science, 1924. Vol. XIV., pp. 469-472.

An application to mineral soils of the method worked out for peat soils by Odén.

XXXV. H. J. Page. *"On the Perchlorate Method for the Estimation of Potassium in Soils, Fertilisers, etc."* Journal of Agricultural Science, 1924. Vol. XIV., pp. 133-138.

The presence of chloric acid in the perchloric acid used for the estimation of potassium in soils, fertilisers and plant material by Davis's method gives rise to very erratic and erroneous results. Every sample of perchloric acid should, therefore, be tested for freedom from chloric acid before being used for the estimation of potassium.

In the application of Neubauer's method of treatment of the soil extract to a soil deficient in carbonates, it is sufficient to add only 0.1 gm. of calcium carbonate to the extract instead of the 0.5 gm. generally used. A considerable economy of perchloric acid is thereby effected.

XXXVI. E. M. Crowther and W. S. Martin. *"The Volumetric Determination of Total Carbonic Acid in Dilute Solutions of Calcium Bicarbonate."* Journal of the Chemical Society, 1924. Vol. CXXV., pp. 1937-1939.

In the course of studies on soil reaction (papers XXVII-XXX), it was found that the standard method for the determination of total carbonic acid (excess barium hydroxide and

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barium chloride titration) gives unsatisfactory results with solutions of calcium bicarbonate and tap waters, owing to the solubility of the precipitated calcium carbonate. If the precipitation is done in the presence of solid calcium carbonate in calcium hydroxide and calcium chloride, good results are obtained with short intervals of standing.

IV. THE SOIL ORGANISMS.

(Bacteriological, Mycological and Protozoological Departments.)

(*a*) BACTERIA.

XXXVII. H. G. THORNTON. *"On the Vibration Method of Obtaining a Suspension of the Bacteria in a Soil Sample, Developed by C. L. Whittles."* Journal of Agricultural Science, 1923. Vol. XIII., pp. 352-353.

A criticism of the results obtained in preliminary work with this bacterial count method.

XXXVIII. H. G. THORNTON and N. N. GANGULEE. *"Seed Inoculation of Lucerne* (Medicago Sativa) *and its Relation to the Motility of the Nodule Organism in Soil."* Nature, December, 1924.

Preliminary results of work on the passage of the nodule organism through soil and of the relation of this to seed inoculation. The addition of soluble phosphate to the milk suspension of bacteria used to inoculate seed was found, in pot experiments, to produce a large increase in nodule numbers.

XXXIX. P. H. H. GRAY and C. H. CHALMERS. *"On the Stimulating Action of Certain Organic Compounds on Cellulose Decomposition by Means of a New Aerobic Micro-organism that Attacks Both Cellulose and Agar."* Annals of Applied Biology, 1924. Vol. XI., pp. 324-338.

A new micro-organism from soil is described that has the power of rapidly decomposing cellulose and agar. It can utilise either of these substances as the sole source of energy, and the ability to decompose these compounds is not lost after long subculturing in the laboratory. The organism has been named *Microspira agar-liquefaciens*. Pure-culture experiments showed that under conditions of adequate aeration this organism will decompose filter-paper to a greater extent when supplied with small quantities of xylose and lignin.

See also paper III.

(*b*) PROTOZOA.

XL. H. SANDON. *"Some Protozoa from the Soils and Mosses of Spitsbergen."* Journal of the Linnean Society (Zool.), 1923. Vol XXXV., pp. 449-475.

The protozoa contained in 3 samples of mud, 8 samples of soil, and 14 samples of mosses from Spitsbergen have been investigated. An abundant fauna was found, most of which was identical with that occurring in the soils and mosses of temperate lands.

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Seven new species of flagellates are described, of which, however, five have subsequently been found in soils from non-arctic regions.

XLI. H. Sandon and D. W. Cutler. *"Some Protozoa from the Soils Collected by the 'Quest' Expedition."* Journal of the Linnean Society (Zool.), 1924. Vol. XXXVI., pp. 1-12.

Soils were examined from St. Paul's Rocks, South Georgia, Elephant Island, Tristan da Cunha, Gough Island, St. Helena, St. Vincent, and San Miguel Azores. The protozoa found in the soils of these remote lands are mostly identical with those found in almost any ordinary English soil. It appears that there is a fairly well defined and characteristic soil protozoan fauna, which is practically ubiquitous. The richest fauna were those found in soils from Tristan da Cunha and Gough Islands, which had been manured with the dung of farm animals for many years. The poorest samples were from South Georgia and St. Vincent, which were all practically sub-soils.

XLII. D. W. Cutler. *"The Action of Protozoa on Bacteria when Inoculated into Sterile Soil."* Annals of Applied Biology, 1923. Vol. X., pp. 137-141.

Three portions of sterile soil were inoculated with bacteria alone, bacteria and amœbæ, bacteria and flagellates. The bacterial numbers were counted daily. The experiment showed that the bacterial population in soil free from protozoa is able to maintain a higher level for a longer period than when protozoa are present; and that the presence of protozoa is one of the factors concerned in keeping the numbers of bacteria below the level they might otherwise attain.

XLIII. R. V. Allison. *"The Density of Unicellular Organisms."* Annals of Applied Biology, 1924. Vol. XI., pp. 153-168.

The density of certain unicellular organisms of known diameter has been measured by Stokes' formula.

The average density of algal cells studied is 1.098 and that for the cysts of Gonostomum sp. 1.057.

The density of the algal cells was found to vary greatly between the larger and smaller sizes, while for intermediate cells it is fairly constant. The total variation in average density of protozoan cysts was much less marked.

During maturation, the cysts of a certain species of Colpoda decreased to one-fourth their original volume, while their average density increased from 1.04 to 1.06.

By the application of the formula of Hehner and Richmond to the density values so obtained, a tentative value has been derived for the actual dry matter of the cells studied. On this basis the dry matter of the young cysts (4 day) of Colpoda sp. amounts to 10.6 per cent. while at the later stage (20 day) it is 15.1 per cent.

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XLIV. R. V. Allison. *"A Note on the Protozoan Fauna of the Soils of the United States."* Soil Science, 1924. Vol. XVIII., pp. 339-352.

The examination of a series of soil samples from widely divergent points in the United States shows a considerable uniformity in the distribution of the more important of the three protozoan sub-phyla, Flagellates, Ciliates and Rhizopoda. The range of type genera was found to be quite similar to that holding for English soils.

From quantitative studies upon these same samples it is suggested that a possible explanation of the divergent conclusions of English and American investigators may be found in the difference in the extent of the protozoan fauna in the respective materials investigated. Thus the biological phenomena which follow the partial sterilization of the soil and which have been so extensively studied by both groups of investigators, though admittedly similar in nature, may have as their fundamental basis groups of organisms of quite diverse natures.

XLV., XLVI. D. W. Cutler and L. M. Crump. *"The Rate of Reproduction in Artificial Cultures of* Colpidium Colpoda. *Parts II. and III."* Biochemical Journal. 1923-24. Vols. XVII., XVIII., pp. 878-886, 905-911.

The rate of reproduction of *Colpidium colpoda* has been tested in cultures derived from one or more animals isolated into small volumes of fluid. It is shown that in the main such cultures are comparable with mass cultures.

The allelocatalytic effect, described by Robertson, has been tested and found not to obtain with *Colpidium* when isolated into fluid whose volume varies from 0.5 to 8.5 mm. A few experiments are given in support of the contention that the rate of reproduction can be accelerated by the addition of small quantities of crushed bacteria or protozoa.

Experimental evidence is given that the number of divisions *Colpidium colpoda* undergoes in definite periods of time is intimately connected with the size of the bacterial population.

Further investigations on the relation between the size of the inoculum and the rate of reproduction demonstrates that the number of divisions steadily decreases as the number of animals inoculated increases.

(*c*) FUNGI.

XLVII. J. Henderson Smith. *"On the Early Growth Rate of the Individual Fungus Hypha."* The New Phytologist. 1924. Vol. XXIII., pp. 65-78.

The fungal hypha elongates at the tip only. The rate of elongation is at first very slow, but steadily increases as time passes, and eventually reaches a maximum value many times greater than the initial rate, and this is maintained for a long period. Different individual hyphæ show considerable differences in the actual rate and in the manner of development, but the majority behave similarly under similar circumstances. Although it increases as the length increases, the rate of extension is not

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constantly proportional to the length of the hypha, but falls off continuously relatively to the length. The extension of branches follows the same process as that of the main hypha, and falls off in rate continuously relatively to the length; but as a rule a branch grows faster than its parent hypha, and in many cases the rate of extension of the total hyphal system (*i.e.*, parent hypha, branches, and sub-branches taken together) is constantly proportional for long periods to the total length. No evidence was found of any actual increase in the growth rate relatively to the amount of substance growing, such as is described in the case of bacteria, nor anything which suggests the formation during the hyphal development of any substance accelerating its growth.

See also "Fungus Pests and their Control, Wart Disease." Papers No. LVI., LVII.

V. THE PLANT IN DISEASE; CONTROL OF DISEASE.

(Entomological, Insecticides and Fungicides, and Mycological Departments.)

(*a*) INSECT PESTS AND THEIR CONTROL.

XLVIII. J. G. H. FREW. "*On the Larval Anatomy of the Gout-fly of Barley* (Chlorops tæniopus Meig.) and *two Related Acalyptrate Muscids, with Notes on their Winter Host-Plants.*" Proceedings of Zoological Society, London, 1923. No. LIV., pp. 783-821.

The metamorphosis of the Gout-fly is fully described with a detailed account of the external and internal anatomy of the mature larva. The structure of the larva in its first and second instars is also discussed. Included in this paper are observations on the metamorphosis of *Meromyza nigriventris* and *Balioptera combinata*—two little known minor pests of winter barley and wheat.

The extent to which all three species utilise wild grasses as winter-hosts has also been examined. *Chlorops tæniopus* has only been found in *Agropyrum repens* among the wild grasses examined. *Meromyza nigriventris* occurs in *A, repens*, *Festuca ovina*, and *Alopecurus pratensis; Balioptera combinata* occurs in *A, repens, Festuca elatior*, *Lolium perenne*, *Holcus lanatus*, and *Agrostis alba*. The following grasses have also been examined but do not appear to function as winter hosts for any species :—*Lolium italicum, Poa pratensis, P. trivalis, P. annua, Agrostis vulgaris, Alopecurus agrestis, Arrhenatherum avenaceum, Anthoxanthum odoratum, Avena pubescens. Cynosurus cristatus*, and *Dactylis glomerata.*

XLIX. J. G. H. FREW. "*On* Chlorops tæniopus Meig." (*The Gout Fly of Barley.*) Annals of Applied Biology, 1924. Vol. XI., pp. 175-219.

Chlorops tæniopus passes through two generations per year. The winter generation is mainly upon couch grass but also occasionally upon winter wheat or upon self-sown wheat or

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barley. The summer generation is mainly upon spring barley, but in seasons unfavourable to the fly couch grass may be utilised. Very rarely wheat is a summer host plant. The life-history is described in detail.

The type of distortion caused to the host plant depends on the stage of growth of the plant when attacked and the degree of distortion of the plants depends upon the rate of growth at the time of attack.

The relation of the fly to the different kinds of host plants is described, particularly as regards the winter generation, and is shown to vary with such factors as date of emergence of the flies, weather conditions during the oviposition period and amount of growth of the different kinds of host plants.

In dull and cool weather the flies will lay few eggs but are stimulated to rapid egg laying by bright and sunny weather. A single fly may lay about 150 eggs. More than one act of coitus is necessary to fertilise all the eggs which a female is capable of laying. The length of life of the imagines is probably about a fortnight for flies emerging in spring, but may be over two months for the autumn emerging flies.

Certain manures (particularly superphosphate) have a marked beneficial effect in reducing the infestation of summer barley by gout fly, owing entirely to their stimulating effect upon the maturing of the ear and the growth of the ear-bearing internode.

While small dressings of nitrogenous manures may reduce infestation, large dressings will not reduce it and may have a tendency to retard growth of the ear and so increase infestation.

Early sowing of spring barley is efficacious in preventing infestation by gout fly.

Preventative measures suggested are early sowing of spring barley, good cultural conditions on the soil, and manuring (*e.g.*, with superphosphate or farmyard manure) to stimulate early growth (*see* paper LXXII.).

L. J. Davidson. *"The Penetration of Plant Tissues and the Source of the Food Supply of Aphids."* Report International Conference Phytopathology and Economic Entomology, Wageningen (Holland), 1923, pp. 72-74.

The food of aphids is the cell sap of plants, which they obtain by penetrating the tissues by means of their piercing, suctorial mouth-parts. The mechanism of piercing and suction and the action of the insects' saliva on the plant tissues is discussed. With *Aphis rumicis* the phloem is an important source of the food supply but other tissues, including the cortex and mesophyll, may be drawn upon, particularly in the case of heavily infested plants.

LI. J. Davidson. *"Factors which Influence the Appearance of the Sexes in Plant Lice."* Science, 1924, p. 364.

A short discussion of the observations of Marcovitch on this subject, in relation to results obtained in experiments at Rothamsted.

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LII. H. M. Morris. *"Note on the Wheat Bulb Fly. (Leptohylemyia coarctata)."* Bulletin of Entomological Research, 1925. Vol. XV., pp. 359-360.

The method of control of this pest is based on the assumption that the eggs are laid in the bare or partially bare soil away from the wheat. A recent examination of the soil fauna of the mangold plots of Barn field at Rothamsted has resulted in the discovery of a number of eggs of this insect. This observation affords confirmation of the recent work of Gemmill who first recorded the finding of eggs in field soil in Scotland.

LIII. F. Tattersfield and H. M. Morris. *"An Apparatus for Testing the Toxic Values of Contact Insecticides under Controlled Conditions."* Bulletin of Entomological Research, 1924. Vol XIV., pp. 223-233.

This apparatus for determining the relative toxicities of contact insecticides is so arranged that successive batches of insects are sprayed under conditions as similar as possible, so that on using various substances at different concentrations, the results are directly comparable. It consists of a glass jar containing in its lid an atomiser, through which is projected by means of compressed air at known pressure a constant quantity of fine spray upon insects placed in a dish inside the jar. Examples are given of results obtained when different concentrations of nicotine are sprayed upon apterous agamic females of *A. rumicis*.

Two notes from the Statistical Department at Rothamsted are included, one analysing the accuracy with which the instrument sprays, and the other giving reasons for regarding the concentrations which kill 50 per cent. of the insects sprayed as the most suitable for the direct comparison of the toxicity of insecticides.

LIV. F. Tattersfield, C. T. Gimingham and H. M. Morris. *"Studies on Contact Insecticides." Part 1. Introduction and Methods. Part 2. A Quantitative Examination of the Toxicity of* Tephrosia Vogelii, *Hook.* to Aphis Rumicis, L. (*The Bean Aphis*). Annals of Applied Biology, 1925. Vol. XII., pp. 61-76.

This paper deals in detail with the insecticidal properties of *Tephrosia Vogelii*, Hook., which, with other species of this genus, occurs abundantly in many parts of the world. The aqueous and alcoholic extracts of its leaves and seeds are shown to be highly toxic to *Aphis rumicis, L.*, the toxicity of the alcohol extract being of the same order as that of nicotine. Extracts of the stems have not proved so poisonous.

The plants of the genus Tephrosia seem to offer possibilities for practical use as insecticides.

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LV. F. Tattersfield, C. T. Gimingham and H. M. Morris. *"Studies on Contact Insecticides." Part 3. A Quantitative Examination of the Insecticidal Action of the Chlor-, Nitro-, and Hydroxyl Derivatives of Benzene and Naphthalene.* Annals of Applied Biology, 1925. Vol. XII., pp. 218-262.

The toxicities of a number of chlor-, nitro- and hydroxyl derivatives of aromatic hydrocarbons to *Aphis rumicis, L.* (adults) and to *Selenia tetralunaria*, Hufn. (eggs) have been determined.

The order of toxicity to aphides of the hydrocarbons and their chlor- and nitro-derivatives is benzene < toluene < xylene < mono-chlor-benzene < p-dichlorbenzene < o-dichlorbenzene < tri-chlor-benzene < nitro-benzene < m-dinitrobenzene. The mono-chlor-nitro-benzenes have about the same toxicity as nitro-benzene; 1.-chlor-2.4-dinitrobenzene is slightly less toxic than m-dinitrobenzene.

Phenol and the three isomeric cresols are toxic to aphides only at high concentrations. The mono-nitro-phenols and cresols are all more toxic than the parent substances, the order of toxicity of the phenols being o-nitro phenol < m-nitro phenol and p-nitro-phenol < 2.4 dinitro phenol which is greater than tri-nitro phenol; the same order applies to the cresols and their corresponding derivatives.

a-chlor naphthalene proved to be the most toxic of the napthalene derivatives tested.

With few exceptions, the relative toxicities of the various compounds to the insect eggs are approximately in the same order as to the aphides. The nitro-derivatives of phenol and the cresols were specially studied and it was shown that, as in the case of aphides, the dinitro compounds are more toxic to eggs than either the mono- or the tri-nitro compounds.

The toxicity of 3.5 dinitro-o-cresol to adults of *Aphis rumicis* and to the eggs of *Selenia teralunaria* is of the same order as that of Nicotine.

Some of the compounds tested, although injurious to foliage, may prove of value as winter spray fluids for trees in a dormant condition and experiments on a practical scale are in hand.

No simple generalisation as to the correlation of toxicity with any one chemical or physical property seems possible in the present stage of our knowledge. It is probable that the nature of the toxic activity depends on chemical constitution, while the intensity of activity is determined by one or more physical properties.

See also paper LXXV.

(*b*) Fungus pests and their control.

LVI. Mary D. Glynne. *"Infection Experiments with Wart Disease of Potatoes,* Synchytrium Endobioticum *(Schilb.)."* Annals of Applied Biology, 1925. Vol. XII., pp. 34-60.

A study of certain conditions controlling infection of potatoes by the winter sporangium of *Synchytrium endobioticum* in the soil and by the summer sporangium in the laboratory has been made with a view to finding a reliable method of pot experiment

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to serve as a basis in soil sterilisation research, and a method for testing immunity or susceptibility more rapidly than is at present done in the field. Experiments on infection by the winter sporangium in the soil have shown that a very high degree of soil moisture is necessary to ensure infection, but this need not be present during the whole of the growth period. It appears most effective when the wet period is in the second month. A high percentage infection is obtained in potato plants grown in soils of very varying physical character. Under the conditions of pot experiments the wart disease organism survives in the soil in the absence of the potato plant for a period of at least a year. There appears to be a dormancy period of about six weeks between soil infection and sporangial germination. The relation of numbers of sporangia in the soil to the incidence of disease is discussed. When favourable conditions were maintained 80-100 per cent. of the plants tested were found to be infected within a period of three months, even in varieties which in the field appear least susceptible. Under conditions less favourable to infection the relative susceptibilities of the several varieties become clearly marked. No wart disease was found under any conditions on immune varieties. Infection of various plants other than the potato was attempted. Small warts were found on three varieties of tomato and on *Solanum nigrum* and *S. dulcamara*, but none on five other varieties of tomato, on *Datura Stramonium*, *Salpiglossis sinuata*, *Hyoscymus niger*, *Atropa belladonna*, *Lycium chinense* or on many common weeds grown in infected soil.

A method is described for infecting sprouting tubers with wart disease by means of summer sporangia. Susceptible varieties subjected to this treatment develop young warts within three weeks, while immunes remain clean. The method can therefore be used for testing immunity or susceptibility in the laboratory.

LVII.—W. A. Roach, Mary D. Glynne, Wm. B. Brierley and E. M. Crowther. "*Experiments on the Control of Wart Disease of Potatoes by Soil Treatment with Particular Reference to the use of Sulphur.*" Annals of Applied Biology, 1925. Vol. XII., pp. 152-190.

As susceptible varieties of potato are still widely cultivated and sporadic outbreaks of wart disease are a serious menace, it was imperative to find a method whereby the winter sporangia of *Synchytrium endobioticum* in contaminated soil could be killed. Previous studies and the unusual difficulties presented by the problem are discussed. Results of experiments extending over four years are recorded.

During 1921-2 pot experiments were carried out to test various chemicals both alone and in conjunction with steam. Steaming the soil proved effective in eliminating the disease, but it offered little hope of being economically possible as a field treatment. The amount of disease was reduced by sulphur, calcium and potassium polysulphides, formaldehyde, dichlor-

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cresol, chlordinitrobenzene and nitrobenzene. Satisfactory infection was not obtained in pot experiments; this method was therefore abandoned in favour of field experiments.

The incorporation of chemicals with the soil in the field was carried out with the Simar Rotary Tiller, great care being taken to ensure very thorough and even distribution. Results suggest that the efficiency of the treatment depends on this thoroughness of incorporation. During 1922 a selection of the chemicals tried in 1921 and others were tested. From these sulphur was selected in 1923 for more extensive study as being the most hopeful because of its efficiency and cheapness.

In 1924, a year of very heavy disease, it was proved at Ormskirk that when the dose of ground sulphur was increased through 1, 2, 3, 4, 5, 10 cwts. per acre the degree of infection was reduced in direct ratio from 73 per cent., the value for untreated soil, to 8 per cent. for an application of 10 cwts. per acre. Doses greater than the latter did not produce proportionate decreases of infection; but there are reasons for thinking that this small amount of disease in certain of the plots was due to recontamination of those plots later in the season. When the results are represented in graphical form the straight line of nearest fit to the experimental values cuts the horizontal axis at a point representing 11.2 cwts. per acre of sulphur; and, in the absence of secondary infection, this quantity of sulphur should be slightly more than the minimum necessary to free the Ormskirk soil of disease.

On the heavy clay soil at Hatfield it was found necessary to use much heavier applications of sulphur (about 40 cwts. per acre) to ensure absolutely clean plots.

Gasworks-spent-oxides, tried as an alternative source of sulphur, proved rather less effective than ground sulphur when equal quantities of sulphur were applied in each case. The result was probably due to the unsatisfactory state of division of the sample of spent oxides.

Sulphur inoculated with *Thiobacillus thiooxydans* showed no increased efficiency over uninoculated sulphur on Ormskirk soils and appeared less effective than the latter on the Hatfield clay.

The elimination of wart disease in the field by sulphur and sulphur compounds was not correlated with the degrees of acidity produced and it would appear that some sulphur product other than sulphuric acid is the active fungicidal agent.

The sulphur treatment will be put to a large scale critical test in 1925-6; but the results to date seem to show that a feasible method of eradication of Wart Disease from contaminated land may have been found.

Many outbreaks are in gardens or allotments situated in the midst of rich potato districts; but owing to legislation limiting the movement of potatoes from relatively large areas surrounding these outbreaks, they are the cause of great losses to neighbouring growers. Hence it is economically possible to spend relatively large sums of money in dealing with these small outbreaks which would be out of the question if treatment at a proportionate cost were to be applied to larger areas. The results described in

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this paper hold out definite hope of the financial possibility of the treatment of small isolated areas and offer some hope even of the possibility of applying such treatment to large areas.

(*c*) PLANT PATHOLOGY.

LVIII. Wm. B. Brierley. "*The Relation of Plant Pathology to Genetics.*" Report of Imperial Conference of Botany, London, 1924. (Cambridge University Press.) pp. 111-119.

A critical discussion of the problem. Where disease is due to growth in unfavourable conditions the problem resolves itself into a study of the genetical qualities of the plant in relation to soil, climate, etc. Where disease is brought about by parasites a complete understanding of any particular case involves the genetic and physiological analysis of both host and parasites and the physical and chemical analysis of the conditions under which the host and parasites have developed and at present exist. Assumption of germinal stability by the plant breeder and of germinal instability by the microbiologist are antithetic and require deeper analysis. Immunity and susceptibility relationships are often confined to pure lines of host and physiological strains of parasites and alterations in external conditions may greatly modify the phenotypic expression of this relationship. The primary factors that determine the appearance of disease in any particular case are (1) the genetic qualities of host and parasite; (2) environmental conditions; (3) relative geographic distribution of host and parasite. An additional factor of importance is the relation of the hygiene of the host to the incidence of disease, the commonly held ideas on which are urgently in need of revision. Most of the past analytic work on the genetics of micro-organisms and the disease relationship needs revising in the light of the following: (*a*) the co-existence of distinct physiological strains in morphological units; (*b*) the possibility, and in certain cases probability, of very considerable genetic complexity and genetic segregation in micro-organisms. Genetic research on bacteria and fungi is incommensurable with that on the more evolved organisms which is the basis of present genetical theory and in the study of the former exact criteria and definite concepts are almost entirely lacking.

TECHNICAL PAPERS.

(*a*) SOILS AND FERTILISERS.

LIX. H. J. Page. "*The Chemistry of the Soil and of Crop Production,*" *in* "*Chemistry in the XXth Century.*" (Benn Bros., 1924.) pp. 225-242.

Following a foreword by Sir John Russell, the subject is discussed with special reference to the progress made since 1900, more particularly by British workers.

LX. B. A. Keen. "*Soil Tilth in Relation to Mechanical Tillage.*" Agricultural Gazette, 1924. Vol. C., pp. 297-298.

An account of the work on soil cultivation being done in the Physical Department. (*See* p. 28.)

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