ROTHAMSTED RESEARCH

Report for 1927-28

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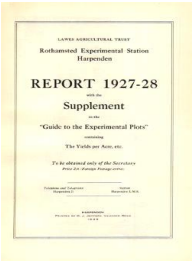

Summaries of Papers Published, 1927, 1928 - I. Scientific Papers :

Rothamsted Research

Rothamsted Research (1928) *Summaries of Papers Published, 1927, 1928 - I. Scientific Papers : ;* Report For 1927-28, pp 55 - 88 **- DOI: https://doi.org/10.23637/ERADOC-1-85**

SCIENTIFIC PAPERS

Published 1927 and 1928 and in the Press.

I.—CROPS, PLANT GROWTH AND FERTILISER INVESTIGATION.

(Botanical, Chemical and Statistical Departments.)

I. E. J. RUSSELL. "*The Institute of Brewing Research Scheme: Fourth Report on the Experiments on the Influence of Soil, Season and Manuring on the Quality and Growth of Barley,* 1925." Journal of the Institute of Brewing, 1927. Vol. XXXIII. (Vol. XXIV., New Series), pp. 104-110.

II. E. J. RUSSELL. "*The Institute of Brewing Research Scheme: Fifth Report on the Experiments on the Influence of Soil, Season and Manuring on the Quality and Growth of Barley,* 1926." Journal of the Institute of Brewing, 1928. Vol. XXXIV. (Vol. XXV., New Series), pp. 307-320.

III. E. J. RUSSELL. "*The Barley Experiments of the Institute's Research Scheme.*" Journal of the Institute of Brewing, 1928. Vol. XXXIV. (Vol. XXV., New Series), pp. 436-446.
See also pp. 26-30 of this Report.

IV. L. R. BISHOP. "*Composition and Quantitative Estimation of Barley Proteins I.*" Journal of the Institute of Brewing, 1928. Vol. XXXIV., pp. 101-118.

Methods have been devised and tested for the quantitative estimation of the amounts of the separate proteins in barley grain. Albumin, globulin and protein breakdown products are extracted by 5 per cent. potassium sulphate solution, 70 per cent. alcohol at 81° C. is used to extract hordein from the residue; the remaining nitrogen probably represents glutelin nitrogen.

These methods have been applied to samples of Plumage-Archer barley grown under varied conditions of season, soil and manuring. These differing conditions influenced the total nitrogen of the grain but not the regular relation shown between the amounts of the separate constituents and the total nitrogen. In the samples the total nitrogen varied from 1.2 per cent. to 2.3 per cent. and (*a*) the percentage of glutelin nitrogen remained constant at 36 per cent. of the total nitrogen, (*b*) the percentage of hordein nitrogen increased regularly with increasing total nitrogen from 28 per cent. with 1.2 per cent. total nitrogen to 40 per cent. with 2.3 per cent. total nitrogen, (*c*) the percentage of salt-soluble nitrogen fell correspondingly from 36 per cent. to 24 per cent. as the total nitrogen increased from 1.2 per cent. to 2.3 per cent.

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There appears to be a balance between the amounts of the various proteins, which adjusts itself according to the amount of total nitrogen present. For these samples therefore the total nitrogen is a good measure of the amounts of the individual proteins and varying " quality " of different samples of the same total nitrogen content is not due to differences in the amounts of the individual proteins.

V. L. R. Bishop. *" Composition and Quantitative Estimation of Barley Proteins II."* Journal of the Institute of Brewing, 1929. Vol. XXXV., pp. 316-322.

The methods for the quantitative estimation of the proteins of barley grain are extended. A detailed fractionation of the salt-soluble substances is worked out. In this extract albumin, globulin, proteose, and peptone nitrogen are estimated as well as nitrogen in the form of simple compounds such as amino-acids (" non-protein " nitrogen). It is concluded that hordein persists from the barley to malt and that the methods found suitable for barley can be applied also to malt.

The importance of fineness and evenness of grinding is shown.

VI. L. R. Bishop. *" The Changes undergone by the Nitrogenous Constituents of Barley during Malting."* Journal of the Institute of Brewing, 1929. Vol. XXXV., pp. 323-338.

As soon as active breakdown commences after steeping, the two insoluble proteins of the endosperm, hordein and glutelin, are broken down at about the same rate to give salt-soluble products chiefly non-protein nitrogen. Then the rate of disappearance of glutelin falls off. Later, the rate of disappearance of hordein becomes very small and the amount of glutelin may increase slightly. At this stage it is kilned.

The falling off in rate of disappearance of glutelin and the suggestion of a subsequent increase point to a resynthesis of this protein in the embryo. The falling off in rate of disappearance of hordein may similarly be accounted for by resynthesis in embryo.

The changes in the nitrogen compounds on the kiln when making pale malts are very slight.

Changes within limits of the amount of water supplied or the length of time on the malting floor produced but little effect on the amounts of different nitrogen compounds in the final malt, owing to the establishment of a balance between breakdown in the endosperm and resynthesis in the embryo.

VII. F. E. Day. *" Small Scale Brewing in the Laboratory."* Journal of the Institute of Brewing, 1928. Vol. XXXIV., pp. 570-573.

A technique has been devised for obtaining a reasonable top yeast crop and beer of normal flavour in the small scale brewings in the Laboratory. Filtration is avoided and brewery conditions are imitated as closely as possible by conducting the fermentation in Thermos flasks. The method can be applied to the comparison of small samples of malts and the examination of hops.

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VIII. W. E. BRENCHLEY. *"The Phosphate Requirement of Barley at Different Periods of Growth."* Annals of Botany, 1929. Vol. XLIII., pp. 89-110.

Experiments have been made in water cultures to test the effect of depriving barley plants of phosphorus after varying initial periods during which it had been supplied, and of supplying phosphorus after initial periods of deprivation.

The provision of phosphate for the first six weeks or longer permitted normal growth to be made, as was shown by the number of tillers, ears, and grains produced, the average number of grains per ear, and the dry weights. With shorter initial periods of phosphate supply growth was seriously depressed in all these respects. If phosphate was withheld for the first four weeks, tiller production was not affected, but no ears were produced. With longer initial deprivation, growth was steadily depressed in all respects, and the type of growth gradually changed from a bushy, succulent character to a thin, lanky, untillered plant bearing the travesty of an ear.

The amount of phosphate absorbed by the plant increased steadily in more or less direct proportion to the length of time phosphate was given at the beginning of growth, but sufficient was taken up in the first six weeks to enable the plant to make its maximum dry weight. The percentage of phosphate in dry matter rapidly increased from this time onwards. The absence of phosphate supply up to the first six weeks of growth caused an extremely rapid drop in the amount of phosphate ultimately taken up by the plant, after which a more gradual decrease occurred with lengthening periods of phosphate deprivation. The probable importance of the presence or absence of phosphorus at the time tillering begins is indicated by reference to further experiments in which phosphate was supplied and withheld for alternate fortnights during growth.

IX. R. A. FISHER. *"A Preliminary Note on the Effect of Sodium Silicate in Increasing the Yield of Barley."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 132-139.

The addition of sodium silicate has been found to increase the yield of barley to a considerable extent, this effect being most marked when no superphosphate is added.

The phosphatic content of the ash is not greatly increased in the grain, and is diminished in one case in the straw; the conclusion from this observation that the silicate does not act by releasing soil phosphates, but as a plant stimulus, overlooks the fact that the addition of silica to the ash naturally reduces the percentage of other constituents, and should be discounted.

The phosphate removed annually in the crop is greatly increased on the plots receiving silicate, even when this removal has continued for many years without replacement.

That additional phosphate is actually made available to the crop on the plots receiving silicate is shown by the increase in the proportion of phosphate in the dry weight of the crop, which appears on all the plots, and at all periods.

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This increase is quantitatively sufficient to account for the increased yield in grain and straw, without postulating the aid of any stimulus to plant growth.

X. T. EDEN AND R. A. FISHER. *"Studies in Crop Variation, IV. The Experimental Determination of the Value of Top Dressings with Cereals."* Journal of Agricultural Science, 1927. Vol. XVII., pp. 548-567.

A simple account of a top dressing experiment carried out at Rothamsted in 1926, with especial reference to the design of such experiments in general, to the statistical analysis of the data, and to the precision attained. The experiment was of 96 plots of winter oats and designed to test with precision the return from top dressings applied early or late, in single or double quantities, and using sulphate or muriate of ammonia. All possible combinations of these conditions were used, the whole having eight-fold replication. The results possessed a higher level of precision than on any previously attained in conditions which allow of a valid estimate of error, the standard error of each comparison being only 1.4 per cent. It is, then, of an order which allows discussion of the monetary return to the industrial farmer in relation to the cost of manure and labour. The experiment is one of a programme of research into top dressings, which it is hoped can be maintained at the same level of precision.

XI. BHAI BALMUKAND. *Studies in Crop Variation, V. "The Relation between Yield and Soil Nutrients."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 602-627.

It is shown (*a*) that it is possible to fit Maskell's Resistance formula (in which the reciprocal of the yield is expressed as the sum of terms each dependent on a specific manurial factor) to experimental data involving the simultaneous variation of two numerical factors by a sufficiently rapid process of approximation, (*b*) that in every case discussed the formula fits the facts within the limits of experimental error estimated from the experiments themselves although formulæ of other types fail strikingly to do so, (*c*) that the parameters appropriate to each nutrient are therefore independent of other conditions and are capable of direct physical interpretation. The interpretation suggested supplies a direct measure of the quantity of each soil nutrient actually available to the plant, and of its specific importance in determining yield.

II.—STATISTICAL METHODS AND RESULTS.

(Statistical Department.)

XII. R. A. FISHER. *"The General Sampling Distribution of the Multiple Correlation Coefficient."* Proceedings of the Royal Society (A), 1928. Vol. 121, pp. 654-673.

By an appropriate linear transformation of the independent variates it may be shown that the sampling distribution of the multiple correlation coefficient does not depend on the whole

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matrix of correlations between these variates, but solely upon the multiple correlation in the population sampled.

The actual distribution (A) may then be easily obtained by similar methods to those by which the distribution of the simple correlation coefficient has been obtained.

The frequency function involves a hypergeometric function of P^2R^2 which is a rational function when n_1 and n_2 are both even, algebraic when n_2 only is even, and reducible to circular functions when n_1 and n_2 are both odd.

The case of large samples yields a series of distributions (B) of great interest, involving Bessel functions, which connect the X^2 distributions with the Gaussian, and are intimately related to a double Poisson summation. Owing to the practical importance of this limiting form, a table of its 5 per cent. points is given up to seven independent variates.

When n_2 is even, the probability integral of the general distribution is expressible in finite terms which are developed in Section 6.

The (B) distribution of Section 5 replaces the X^2 distribution in the analysis of variance if the squares summed are non-central. An analysis of variance so extended leads to a third group of distributions (C), closely related to (A), and tending like it to a common limit (B). The distinction between (A) and (C) arises from the fact that in cases proper to the multiple correlation the central displacements will vary from sample to sample owing to variations in the second order moment coefficients of the independent variates, and for such cases (A) is the correct distribution. The type (C), however, is of frequent occurrence owing to the absence or irrelevance of such variation.

XIII. R. A. FISHER. *"On a Distribution Yielding the Error Functions of several Well-known Statistics."* Proceedings of the International Mathematical Congress, Toronto, 1924, pp. 805-813.

When the exact sampling distributions of a number of the statistics in most general use came to be worked out, it appeared that apart from avoidable differences in notation, nearly all were examples of three related types of distribution. Two of these had been previously found and their numerical values made in part available. In 1900, Pearson had established the distribution of his measure of discrepancy X^2 used in testing goodness of fit. Although as given this distribution was incorrect, the correction, so long as efficient methods of fitting are used, does not change the form, but only the particular member of the series to be employed. An identical distribution was subsequently found by "Student" for the variance as estimated from a normal sample, and by the author for the index dispersion for the Poisson and Binomial series. The distribution of t first found by "Student" in studying the mean of a unique sample, is also exact over a much wider range, and gives the distribution also of regression coefficients of all orders. The third distribution, that of z, which may be regarded as a generalisation either of that of X^2 or of t, completes this group of theoretical distributions and supplies the solution for intraclass correlations, the goodness of fit of regression

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formulæ, the comparison of variances and the significance of multiple correlation and correlation ratios.

XIV. R. A. Fisher and J. Wishart. *"On the Distribution of the Error of an Interpolated Value, and on the Construction of Tables."* Proceedings of the Cambridge Philosophical Society, 1927. Vol. XXIII., pp. 912-921.

The development of simple interpolation formulæ involving only even differences, has favoured the increased use of formulæ of high order; while the theoretical study of the remainder term makes it possible to design tables for which such formulæ are rigorously valid. This paper develops the theory of the distribution of the error of interpolated values, and shows that these will always have a higher precision than the tabular entries, and if the errors of the latter are normally distributed and independent, those of the former will be normally distributed also, with a variance which for high order formulæ tends to equality. This will not be the case for tables "correct to the nearest figure" in which the error distributions of the tabular entries will be rectangular, and those of the interpolate will have a complicated distribution. The advantages both in convenience and in precision of not cutting down tables as originally calculated, so as to be correct to the nearest figure are therefore to be considered in the publication of tables.

XV. J. Wishart. *"On Errors in the Multiple Correlation Coefficient due to Random Sampling."* Memoirs of the Royal Meteorological Society, 1928. Vol. II., No. 13, pp. 29-37.

The use of the multiple correlation in meteorological and agricultural problems is common where the effect of a number of independently varying factors on, say, the weather of a particular locality, is investigated. An experimental study is made of the kind of values, with their frequency of occurrence, which would arise from chance factors which had in reality no influence on the phenomenon studied. The mathematical theory for this particular case is now complete, and it is shown how the probability of occurrence of any value can be calculated. This method of testing the significance is recommended in place of the more usual probable error, for the distribution is far from normal.

XVI. J. Wishart. *"Table of Significant Values of the Multiple Correlation Coefficient."* Quarterly Journal of the Royal Meteorological Society, 1928. Vol. LIV., pp. 258-259.

This table gives the values of the multiple correlation coefficient that would occur in random sampling from uncorrelated material for the 1 and 5 per cent. levels of significance, and is based on the theory outlined in the preceding memoir. It is carried as far as six independent variates and up to samples of 100.

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XVII. J. WISHART. *" Le traitement correct des Problémes de Corrélation Multiple en Météorologie et Agriculture."* Report of the Association Française pour l'avancement des Sciences, 1928.

The use of the multiple correlation coefficient and its testing by the preceding significance tables is explained, and examples, taken from the weather forecasting work of Sir Gilbert Walker, are worked out. Comment is made on the recent correspondence in " Nature " on the use of the probable error in correlational work.

XVIII. J. WISHART. *" The Generalised Product Moment Distribution in Samples from a Normal Multivariate Population."* Biometrika, 1928. Vol. XXA., pp. 32-52.

The distribution of the variance was first given by " Student " in 1908. The next advance was in 1915, when R. A. Fisher, for a two-variate population, gave the simultaneous distribution of the three second order moment coefficients, namely the two variances and the cross product moment (or co-variance). In this paper the problem is generalised to include any number of variates, and the multiple distribution of all second order product moment coefficients is deduced. A table follows giving the moment coefficients of this distribution, as far as the fourth order and eight variates.

XIX. J. WISHART. *" A Problem in Combinatorial Analysis giving the Distribution of Certain Moment Statistics."* Proceedings of the London Mathematical Society, 1929. Series 2, Vol. XXIX., pp. 309-321.

The method outlined in the previous paper for deducing the moments of the distribution from a particular generating function is tedious, and it is here shown that it is, after all, only a particular case of a more general problem whose solution can be reached through the theory of combinatorial analysis. The correspondence between the theories is indicated, and the special problem, which can be considered as a ring arrangement of rods, is worked out in full. Finally, an operational solution is demonstrated, and the arithmetical procedure for building up any required result is illustrated in an example.

XX. J. WISHART. *" Sampling Errors in the Theory of Two Factors."* British Journal of Psychology, 1928. Vol. XIX., Part 2, pp. 180-187.

It is a mathematical consequence of the theory that any ability can be resolved into two factors, one general and the other specific, that the tetrad difference of correlation coefficients between any four abilities should vanish, within the limits of random sampling error. A modified definition of the tetrad is introduced in order that the distribution reached in Paper No. XVIII. should be capable of application to this problem. An exact formula is then deduced for the standard error of the tetrad, and this is applied to some published results of psychological experiments.

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XXI. T. N. HOBLYN. *"A Statistical Analysis of the Daily Observations of the Maximum and Minimum Thermometers at Rothamsted."* Quarterly Journal of the Royal Meteorological Society, 1928. Vol. LIV., pp. 183-202.

Daily records of maximum and minimum temperature at Rothamsted are available for 49 years. This paper gives the means, variances and covariances for each month, and analyses the variance and covariance into portions ascribable to variation from day to day and from year to year.

XXII. R. A. FISHER AND T. N. HOBLYN. *"Maximum and Minimum-correlation Tables in Comparative Climatology."* Geografiska Annaler, 1928. Vol. III., pp. 267-281.

In connection with Paper No. XXI. on Maximum and Minimum Temperature Variations at Rothamsted, the opportunity was taken to prepare and publish for the purposes of comparative climatology two-way tables of these variates for each month of the year for the first 49 years of experience at Rothamsted. The tables are supplemented by Analyses of Variance in which the year to year variation is distinguished from the day to day variation within the same year.

XXIII. R. A. FISHER AND BHAI BALMUKAND. *"The Estimation of Linkage from the Offspring of Selfed Heterozygotes."* Journal of Genetics, 1928. Vol. XX., pp. 79-92.

Five methods of solution are given of the statistical problem presented by typical linkage data. The example chosen shows the various errors into which the use of inefficient statistics leads. Of the efficient methods, the method of maximum likelihood possesses the advantage that it may be applied directly to any analogous problem, and is related in a previously unsuspected way to the measure of discrepancy χ^2. The product ratio method, for using which a table is provided, enjoys the practical advantages of other efficient solutions, and is in addition unaffected by differential viability, if this is caused by one factor only. The method of minimum χ^2, unlike the other two, is laborious in computation and seems to possess no special theoretical interest.

XXIV. R. A. FISHER. *"The Possible Modifications of the Response of the Wild Type to Recurrent Mutations."* American Naturalist, 1928. Vol. LXII., pp. 115-126.

The reaction of the wild type to mutations is known in many cases to be capable of a somewhat rapid modification in experimental conditions, by the selection through differential viability of factors capable of modifying this response.

It may be calculated that with mutation rates of the order of one in a million the corresponding selection in the state of nature, though extremely slow, cannot safely be neglected in the case of the heterozygotes.

The observed behaviour of multiple allelomorphs largely

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supports, though that of specific modifiers seems to oppose, the view that complete dominance generally may be regarded as a product of such selective modification.

XXV. R. A. FISHER. *"Two Further Notes on the Origin of Dominance."* The American Naturalist, 1928. Vol. LXII., pp. 571-574.

In connection with the previous paper (No. XXIV) the evidence of the behaviour of the cotton mutant, *Crinkled Dwarf,* investigated by Dr. S. C. Harland, is cited as demonstrating the natural evolution of dominance. This mutant is a clear recessive in the Sea Island cottons in which it occurs, but on crossing with other species the dominance of the wild type is found to be conditioned by a group of probably numerous modifiers in which the Sea Island has come to differ from other cottons.

It is suggested that the anomalous dominance of several breed characteristics in domestic poultry may be explained by the incidence of selection in early stages of domestication when the domestic flocks were frequently sired by wild jungle fowls.

XXVI. R. A. FISHER AND L. H. C. TIPPETT. *" Limiting Forms of the Frequency Distribution of the Largest or Smallest Member of a Sample."* Proceedings of the Cambridge Philosophical Society, 1928. Vol. XXIV., pp. 180-190.

The distribution of the greatest or least of a sample of n may be derived from that of the population sampled. If it tends to any limiting form as the size of the sample is increased, its distribution must obey a functional relation the solution of which is here given, with a discussion of the criteria which determine the limiting form, and of the gradual approach to the limit shown in normal samples.

XXVII. R. A. FISHER AND E. B. FORD. *" The Variability of Species in the Lepidoptera, with Reference to Abundance and Sex."* Transactions of the Entomological Society of London, 1929. Vol. LXXVI., pp. 367-384.

The frequency distribution of depth of pigment in the ground-colour of the fore-wings of 35 species of British moths has been obtained by comparison of over 5,000 specimens with a standard colour scale.

For comparison of variabilities of groups of different average tint the standard deviations have been adjusted to eliminate any arbitrary elements which might have been introduced by the scale employed.

The mean tint is darker in the females than in the males, and is also darker in the more abundant than in the less abundant species.

Even after adjustment the mean variance is about 30 per cent. higher in females than in males, and is in both sexes greatest in the abundant species, and at least in those which are less than common.

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It is also possible, though the difference is not in this material statistically significant, that the species with wider range are, in any one locality, the more variable.

The association of variability with abundance accords with an early generalisation of Darwin's, and with the theory that variability is determined by a balance between the influences of mutations and selection. This theory is insufficient numerically to account for the large differences in variability between the sexes.

In view of the frequency of polymorphism, and other marked variations, in the females as opposed to the males in Lepidoptera, it is suggested that the male sex hormones may inhibit the action of a number of the factors influencing the development of pigment, as in the well-known sex-controlled variation. The suggestion of Goldschmidt that there exist pigmentation factors in the Y chromosome capable of interaction with outosomal factors to cause pigmentary differentiation is an alternative view which may account for a few cases. This should result in purely female unisexual polymorphism (except for the possibility of occasional crossing-over between the X and Y chromosomes), but it is almost certainly an infrequent phenomenon. It is possible that sexual selection may, in part, be responsible for the complete inhibition of mimetic patterns in the males of certain mimetic species.

XXVIII. R. A. Fisher. "*Triplet Children in Great Britain and Ireland.*" Proceedings of the Royal Society (B), 1927. Vol. 102, pp. 286-311.

Measurements taken at a fixed age of 115 surviving triplet children, are reported upon in respect of the average growth attained, which is not appreciably different from that of children by single births; of the degree of resemblance between pairs of like and unlike sex, which confirm in entirely independent material the conclusion drawn from Lauterbach's measurements of twins; and of the inheritance of the twinning tendency which, in opposition to the view developed by Weinberg, indicates inheritance of diembryony on the paternal side.

XXIX. R. A. Fisher. "*On Some Objections to Mimicry Theory, Statistical and Genetic.*" Transactions of the Entomological Society of London, 1927. Vol. LXXV., pp. 269-278.

The statistical reasoning which led Marshall to dispute the applicability of Müller's theory to the mimetic approach of a more numerous to a less numerous form, is shown to be unsound, and the validity of Müller's argument is verified. The contention of Punnett that in certain cases mimetic forms must have arisen by saltations falls with Marshall's argument on which it is based. The more recent study of modifying factors shows that the Mendelian inheritance observed in polymorphic mimics does not show that these forms were not gradually evolved by natural selection; while the stability of the gene ratio of these factors implies selective action.

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III.—THE SOIL.

(*a*) Mechanical Analysis.

(Chemical, Physical and Statistical Departments.)

XXX. A Sub-Committee of the Agricultural Education Association. *"The Revised Official British Method for Mechanical Analysis."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 734-739.

A Sub-Committee of the Agricultural Education Association, with Dr. Keen as convenor, proposed in 1926 a new method of mechanical analysis that was officially adopted by the Association. (Papers XXII. and C., Report 1925-26.) At the 1927 meeting of the International Society of Soil Science an agreed international method was adopted which did not differ greatly from the New British method. In consequence, the Agricultural Education Association Sub-Committee decided to make the necessary changes in its recommended method to bring it into line with the international proposals, and the present paper contains an account of the reasons for the change and the actual alterations involved. The full details of the new method, known as the "Revised Official Method," have been accepted and published (see Technical Paper No. CXVIII).

The main differences are that the fractions are weighed as oven dry and not after ignition, and the grouping of the fractions has been altered to the Atterberg scale.

XXXI. E. M. Crowther. *"Nomographs for use in Mechanical Analysis Calculations."*...Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 399-404.

To facilitate the more general adoption in routine work of the temperature correction for the viscosity of water in mechanical analysis, a nomograph has been prepared giving by a direct reading the times or depths of sedimentation equivalent to those desired at a standard temperature of 20° C. In a second nomograph the logarithms of the settling velocities are connected with (1) the experimental depths and times and (2) the temperature and "equivalent diameter" evaluated on the basis of Stokes' Law.

XXXII. E. M. Crowther. *"The Direct Determination of Distribution Curves of Particle Size in Suspensions."* Journal of the Society of Chemical Industry, 1927. Vol. XLVI., pp. 105-107T.

An apparatus is described for obtaining continuous size distribution curves of suspensions through measurements of the changes with time of the density at a given depth. A highly sensitive differential liquid manometer connected between two points near the base of the sedimenting column is used to secure sufficient magnification for direct readings. Since the readings are proportional to the concentration at a defined depth they may be plotted against the times, or the logarithms of the times, to give directly a summation percentage curve for particle size.

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XXXIII. E. M. CROWTHER. *" A Manometric Apparatus for the Direct Determination of Summation Percentage Curves in Mechanical Analysis."* Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 394-398.

See Paper No. XXXI. for abstract.

(*b*) PHYSICAL PROPERTIES.

XXXIV. B. A. KEEN. *" First Commission Soil Mechanics and Physics."* Soil Science, 1928. Vol. XXV., pp. 9-20.

This is a critical review of recent progress in Soil Physics, partly based on the papers presented to the International Congress of Soil Science, at Washington, D.C., in 1927.

XXXV. B. A. KEEN AND J. R. H. COUTTS. *" 'Single Value' Soil Properties : A Study of the Significance of Certain Soil Constants."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 740-765.

Numerous attempts have been made to devise an experimental method that, applied to a variety or a series of soils, enables them to be placed in an order closely reflecting their field behaviour or their most important physical characteristics. Such a method is called a " single value " determination, as it endeavours to specify the soil by a single number, in distinction to the group of figures obtained, for example, from a mechanical analysis. A number of these methods are discussed in the present paper, which contains an account of a detailed investigation on 39 soils of certain single value determinations.

The methods selected for study were chosen because (i) they required only simple apparatus, and (ii) they appeared to be related to some distinct characteristic of the soil.

The list of measurements was as follows :—

(*a*) percentage of clay ; (*b*) moisture content of soil in equilibrium with atmosphere of 50 per cent. relative humidity (the ordinary " air-dry moisture content " which was also determined, is close to this value) ; (*c*) ignition loss of the dried soil ; (*d*) moisture content at the " sticky " point, which is defined as the point at which a thoroughly kneaded plastic mass of the soil is just about to stick to the fingers or to a knife.

An important feature of the present investigation was the repetition of the above measurements after the soils had been treated with hydrogen peroxide. Our present knowledge indicates that this removes the humified and non-structural part of the organic matter without exercising more than a small solvent action on the mineral portion of the soil. Comparison of the single-value results for the original and peroxide treated soils thus gives an opportunity of approximately comparing the relative contributions of the organic and mineral parts of the soil. The main results are set out below :—

Correlation coefficients obtained for the various pairs of quantities examined express the general fact that the heavy clay soils have the highest ignition losses, moisture contents and sticky points.

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An increased correlation between clay and sticky point for the peroxide treated soils suggest that the sticky point value is controlled both by the organic matter and some property related to the clay content.

When the associations are further examined by partial correlation coefficients, the sticky point is shown to be largely controlled by the colloidal and inorganic colloidal material, while the moisture content at 50 per cent. relative humidity is largely controlled by the actual clay content. There is independent evidence that this moisture is held in the minute interstices between the clay particles.

The sticky point approaches a lower limit of about 16 per cent. moisture content with very sandy soils containing little organic matter. This value is close to 14.6 per cent., which is the saturation moisture content of an ideal soil in closest packing, and it is shown that the pore space of this ideal soil and of the kneaded blocks of actual soil have approximately the same value. Hence the value of the sticky point moisture content is made up of (*a*) 16 per cent. of water held in the pore space, unassociated with colloidal material, and (*b*) water associated with colloidal material. The division of the latter quantity into water associated with organic matter and inorganic clay colloids can be very approximately effected by assuming (i) that the difference between ignition losses of original and peroxide treated soil measures the effective organic matter, and (ii) that the ignition loss of the peroxide treated soil (less the organic matter still present) represents the clay colloid. On these assumptions it appears that the organic colloid takes up about 4.4 times its own weight of water, and the inorganic clay colloid 2.7 times its own weight. The approximate nature of the comparison must be emphasised, owing to the limitations in the assumptions on which it is based. If the actual clay content be taken instead of the ignition loss of the peroxide treated soil, as a measure of the inorganic colloid, the clay on a unit weight basis is only one-ninth as effective as the organic matter.

A comparison is made of the variation of sticky point determinations made by different workers, and it is shown that satisfactory agreement can be secured after a little experience of the method.

The importance is stressed of introducing single value methods as an adjunct to the modern system of soil classification, and into soil physics.

XXXVI. B. A. Keen. *"Some Comments on the Hydrometer Method for Studying Soils."* Soil Science, 1928. Vol. XXVI., 261-263.

Bouyoucos has developed an empirical method of studying soils, based on the reading of a hydrometer placed in a suspension of the soil in water that has stood for 15 minutes to allow the coarser particles to settle. In Paper No. XXXIV., it was pointed out that the method was essentially qualitative, since an appreciable density gradient must exist in the suspension between top and bottom of the long hydrometer bulb after so short a period as 15 minutes. Later, Bouyoucos (Soil Science, 1925, 25 pp. 365-369) claimed that this statement was not justified, and gave some

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results to support his claim. The present paper consists of an examination of these figures, which show, as would be expected, that there is an appreciable density gradient, and the actual technique employed by Bouyoucos is then stated in exact physical terms : it consists in measuring at an arbitrary time the average density of a layer of suspension several centimetres in length whose density is continually changing both with depth and time in a manner depending on the particle-size distribution curve of the soil, and therefore varying from soil to soil. The method is therefore essentially qualitative, although in the present state of our knowledge it has some value as an empirical determination.

XXXVII. W. B. Haines. *" Studies in the Physical Properties of Soils, IV. A Further Contribution to the Theory of Capillary Phenomena in Soil."* Journal of Agricultural Science, 1927. Vol. XVII., pp. 264-290.

This paper examines in detail the manner in which the moisture in soil is distributed over and between the soil particles. The usual conception of an ideal soil (an assemblage of equal sized spheres in regular packing) is employed, and experimental measurements are made with various materials approximating to this definition. It appears from considerations of the pressure deficiency produced by curvature of the water film surfaces, that there are two possible stable positions for a film of given pressure deficiency : one in which the water exists as an open tunnel, and the other in which the tunnel is filled and closed by a concave film at each end. The fact that these interchangeable forms are possible implies that over a wide range of moisture content the pressure deficiency remains constant, falling rapidly to zero at saturation, and rising theoretically to an infinite value at the dry end of the scale. The experimental results conform this conclusion when allowance is made for the impossibility of packing the material in the regular manner postulated for the ideal soil.

The curve connecting pressure deficiency with percentage of pore space occupied by water is shown also to represent the relation between height above the water table and moisture content at that height for a column of soil whose lower end stands in water.

The suction or pressure deficiency which is necessary to draw an air-water interface into the pores of the soil characterises the capillary behaviour over a considerable moisture range, and the term " entry value " is suggested for it.

XXXVIII. R. A. Fisher. *" Further Note on the Capillary Forces in an Ideal Soil."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 406-410.

The new observations of Haines on the pressure deficiency of liquid in a soil-like aggregate confirm the theoretical deduction that the pressure deficiency falls off with increasing water content, but do not justify his belief in a high static stress as saturation is approached.

A theorem is established connecting the static stress at any water content with the pressure deficiency and the dry area of the surface. This, together with general considerations of the

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energy conditions of physical equilibria, appears to dispose of the two assumptions from which the high values for the cohesive stress at saturation have been deduced.

XXXIX. E. M. CROWTHER. *"Some Physical Properties of Heavy Alkaline Soils under Irrigation (in the Sudan Gezira)."* Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 429-433.

The value of some extremely simple physical methods of studying soil texture is illustrated by measurements on the heavy alkaline soils of the Sudan Gezira. The field density of the soil shows a marked maximum at a depth of 80 cms., but the impermeability to water of the soil at this depth is not entirely due to the closeness of packing, since sieved soil samples, uniformly packed in glass tubes, show a pronounced minimum in the rate of water movement at this depth. The rate of capillary rise of water into sieved soils in glass tubes affords a simple measure of soil texture which is useful for soil survey purposes. In good cotton soils, the rate of capillary rise was about 50 per cent. higher than in bad soils.

XL. B. A. KEEN. *"The Limited Rôle of Capillarity in Supplying Water to Plant Roots."* Proceedings and Papers of the First International Congress, 1927. Vol. I., pp. 504-511.

The pore space in soils may be regarded as consisting either of an assemblage of small cellular units or of irregular thread-like capillary tubes. The latter conception is the one customarily employed in text-books when the movement of soil moisture is under consideration. It leads, however, to values for the capillary rise of water in soils that are much higher than those found experimentally.

The attainment of equilibrium conditions of moisture in a soil column is a slow process, and moisture distribution conditions in the field are therefore essentially dynamic. The present paper is a preliminary account of the relation between evaporation factors and the daily level of the ground water table in large cylinders of soil exposed to field conditions and kept uncropped. From the data, which included the period of the great drought in 1911, it is possible to construct curves showing how the free water level would fall in an initially water-logged soil during a continuous and unbroken drought. It is found that after the water table has receded some 70 cms. below the surface in a heavy loam soil, the subsequent fall is very slow, and in a further six months the level falls only an additional 20 cms. This slow movement shows that capillary action is practically ineffective in raising water through a higher distance than 60-80 cms. in a heavy soil under field conditions, and the result emphasises the importance of those cultivation methods intended to protect the moisture supply in the soil from evaporation at the surface.

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XLI. G. W. Scott Blair and E. M. Crowther. *"The Flow of Clay Pastes through Narrow Tubes."* Journal of Physical Chemistry, 1929. Vol. XXXIII., pp. 321-330.

Laboratory studies of the physical and physico-chemical factors concerned in the production of soil tilth in the field can be made in a variety of ways. This paper gives an account of the behaviour of clay and soil pastes when they are forced through a capillary tube under pressure. The experimental method has been used by a number of workers and for a wide range of plastic materials, but neither the apparatus nor the theoretical treatment can be regarded as completely satisfactory. Improvements were therefore introduced in the design of the apparatus: a bulb is provided at each end of the capillary and the paste is sheared alternatively from one bulb to the other; the apparatus is bodily tilted during the experiment to keep the level of the paste in the two bulbs the same, so that no correction is required for hydrostatic head; the amount of flow under given constant pressure is measured by a calibrated flowmeter consisting of a sensitive inclined alcohol manometer that records the pressure of the displaced air as it escapes through one of a series of capillaries, selected as convenient for the velocity of paste flow under measurement.

It is known that the relationship between the amount of material flowing in unit time and the pressure applied is not the simple proportionality obtained with true fluids under the same conditions for which the Poisuille equation holds. Numerous attempts have been made to obtain a modified Poiseuille equation for the flow of pastes. The one here considered is due to Buckingham who predicted that with increasing pressures the material would flow successively as (*a*) a solid plug, (*b*) a solid plug moving in an outer stream line sheath, (*c*) entirely stream line flow. These conclusions are shown experimentally to be correct, but in addition there is a stage that precedes the plug flow, in which no movement at all occurs until the pressure reaches a certain minimum value; the necessary modification of the Buckingham equation to include this effect is given. When the volume of flow in unit time is plotted against the pressure employed, the points for the plug flow and the complete stream line flow lie on straight lines. A constant independent of the diameter of the capillary can be derived from the slope of each line, and the ratio of these constants is independent of the concentration of the material used over a wide range. The value of the ratio appears to depend on the nature and geological origin of the material.

XLII. G. W. Scott Blair. *"Ueber die Geschwindigkeitsfunktion der Viskositat disperser Systeme."* (On the speed-function of Viscosity in disperse systems), "Kolloid Zeitschrift," 1929. Vol. XLVII., pp. 76-81.

Ostwald and his school have for some years been collecting a great mass of data relating the amount of material passing through a capillary tube in unit time and the pressure applied to the material. For colloidal materials which are not true fluids

many other workers have found that for a certain region of pressures a straight line is obtained by plotting the pressure direct against the flow per unit time, though this straight line does not pass through the origin.

Ostwald's treatment, however, is more elaborate and involves the logarithms of the pressure and flow. This necessitates the friction coefficient (equivalent to viscosity in a pure fluid) having dimensions dependent on the material used and on the conditions of experiment.

In this paper it is shown that much of the data obtained by Ostwald and others can be equally well interpreted on the simple relationship already mentioned. This has the further advantage that the friction coefficient is of normal dimensions.

(*c*) Soil Cultivation.

XLIII. W. B. Haines and B. A. Keen. *"Studies in Soil Cultivation, IV. A New Form of Traction Dynamometer."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 724-733.

The original form of dynamometer (Report 1925-26, Paper XXX.) has now been replaced by a new type described below that has many advantages.

The instrument consists of (*a*) an hydraulic link weighing 16lb., and placed in the hitch, (*b*) a recording mechanism weighing 15lb., carried on any convenient part of the implement, and (*c*) a control box weighing 4lb., carried by the operator. When packed in a stout box for transit, and with all accessories, the total weight is less than 100lb. The instrument is of robust construction, and has a minimum number of moving parts. Adjustments for stylus pressure, etc., are provided, but the necessity for using them hardly ever arises.

The instrument operates by recording the amount of movement in a Buordon tube filled with oil and connected by narrow bore copper tubing to the oil in the hydraulic link. A number of Bourdon tubes is provided, of different strengths. These tubes are easily interchangeable so that the instrument can be used, with the same percentage accuracy for all types of work from the lightest to the heaviest.

XLIV. W. B. Haines and B. A. Keen. *"A New Dynamometer, suitable for all types of Horse and Power-Drawn Implements."* Proceedings and Papers of the First International Congress of Soil Science, Vol. I., Part II., pp. 405-411.

See Paper No. XLIV. for abstract.

XLV. B. A. Keen. *"The Value of the Dynamometer in Cultivation Experiments and in Soil Physics Research."* Proceedings nd Papers of the First International Congress of Soil Science, 1927. Vol. I., pp. 412-428.

This Paper summarises the work already described in Papers XXX., XXXI., and XXXII., of the 1925-26 Report. In addition an account is given of later work in which variations in the resist-

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ance of the subsoil were recorded by the dynamometer during the operation of mole drainage. The field in question was known to have an irregular subsoil, patches of gravel occurring in the clay. The boundaries and extent of these patches were sharply defined by the dynamometer results, and it was therefore possible to construct a map giving their positions in detail. Without the dynamometer this information would only have been obtained—and only then in a very approximate form—by laborious digging or boring of many holes.

(*d*) Organic Chemistry.

XLVI. H. J. Page and C. E. Marshall. *"The Origin of Humic Matter."* Nature, 1927. Vol. CXIX., p. 393.

Fractionation of humic material by sulphurous acid gave substances resembling lignosulphonic acids. The possible relationship between lignin and natural humic acids is discussed.

IV.—THE SOIL POPULATION AND ITS BEHAVIOUR.

(Bacteriological, General Microbiology, Mycological, and Entomological Departments.)

(*a*) Bacteria.

XLVII. E. J. Russell. *"The Present Status of Soil Microbiology and its Bearing upon Agricultural Practice."* Proceedings and Papers of the First International Congress of Soil Science, June, 13-22, 1927, Washington, D.C. Vol. I.

XLVIII. P. H. H. Gray and H. G. Thornton. *"Soil Bacteria that Decompose Certain Aromatic Compounds."* Centralblatt fur Bakteriologie Abt. II., 1928. Vol. LXXIII., pp. 24-96.

Many types of soil bacteria have been isolated that can decompose the aromatic compounds phenol, meta-cresol, and naphthalene, which are used as soil sterilising agents. Several of them can also utilise one or more of the following compounds: ortho-cresol, para-cresol, phloroglucinol and resorcinol. One organism has been isolated that can utilise toluol. Pure cultures of the bacteria use these compounds as sole sources of energy in mineral salts media containing inorganic nitrogen. Organisms without spores grew in media containing 0.1 per cent. phenol, but were killed by a concentration of 0.2 per cent. The bacteria are widely distributed in Great Britain, and have been found in soils from Norway, the Tyrol, and from islands in the South Atlantic. They are most often found in arable soil and, in the Rothamsted plots, rarely occur in unmanured soil. One species (*Mycobacterium agreste* n.sp.) is more abundant in dry than in wet districts. Out of 245 soil samples examined, 146 yielded the bacteria, and from these 208 strains were isolated that attack either phenol, meta-cresol, or naphthalene. From a study of their morphology and growth characters the strains have been classified into seven genera and 25 species, which are described. A new genus, *Mycoplana*, has been formed to include an aberrant

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type having motile branch cells. When soil is treated with phenol an increased bacterial population ensues, which is composed largely of one morphological type (*Micrococcus sphaeroides* n.sp.) that can decompose phenol in pure culture.

XLIX. H. G. THORNTON. *"The Influence of the Number of Nodule Bacteria as Applied to the Seed upon Nodule Formation in Legumes."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 373-381.

In a field trial with lucerne grown from seed treated with varying doses of culture, it was found that the numbers of nodules were increased as the dose was raised from 2,500 to 20,000 organisms per seed (56 to 7lb. of seed per culture). Storing the seed for periods up to 28 days between inoculation and sowing caused some loss in the nodule numbers. This loss was greatest between 1 and 7 days' storage.

The difference in dose of culture and in period of storage did not significantly affect the crop subsequently obtained from the inoculated plots, whose yield was, however, much above the uninoculated. In a pot experiment made with runner beans, it was found that increase in the dose of culture above 1,280,000,000 organisms per pot containing six seeds was still capable of increasing nodule numbers but not to an extent proportional to the increase in dose.

The experiment does not exclude the possibility that the restriction in effect of very heavy doses may be due to the soil population becoming saturated with the bacteria. On the other hand, observations on lucerne plants grown aseptically on agar and inoculated with a pure culture, showed that even when excessive numbers of bacteria immediately surrounded the root hairs, only 4 per cent. of these were infected.

L. H. G. THORNTON. *"The Rôle of the Young Lucerne Plant in Determining the Infection of the Root by the Nodule Forming Bacteria."* Proceedings of the Royal Society (B), 1929, pp. 481-492.

The appearance of nodules on seedlings of Lucerne (*Medicago sativa. L.*) coincides with the opening of the first true leaf. There is evidence that before this leaf opens the nodule bacteria do not, as a rule, infect the root-hairs.

The delayed infection is due to the plant, and not to any delay in the development of infective power by the bacteria.

When young inoculated seedlings whose first leaves are still closed are grown intermingled with older plants a considerable number of nodules will develop on them, although scarcely any are formed on control seedlings of the same age, grown by themselves.

The solution surrounding the roots of seedlings whose first leaves are expanded, has an influence in stimulating the appearance of nodules on younger seedlings and increases the growth of the nodule organism on agar. The solution surrounding the roots of younger seedlings has no such effect.

The active substance inducing nodule appearance when the first leaf opens is not formed in this leaf, since the removal of the leaves while still closed has no effect on nodule appearance.

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LI. H. G. THORNTON. *"The 'Inoculation' of Lucerne (Medicago sativa) in Great Britain."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 48-70.

The Paper discusses experiments laid down at 39 centres in Great Britain to test the value of seed inoculation for lucerne. In the West and North of England the treatment greatly benefited the lucerne and often enabled a crop to be obtained where the untreated lucerne failed.

In the midland and south-central counties, inoculation usually produced a temporary improvement, the untreated plant eventually catching up with the inoculated. In East Anglia and Kent, untreated lucerne usually developed plenty of nodules. There is evidence that, when the seed is inoculated, the chances of success with lucerne are on the whole as good in the West and North of England as they are in the South-east.

LII. H. L. JENSEN. *"On the Influence of the Carbon-Nitrogen Ratios of Organic Material on the Mineralisation of Nitrogen."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 71-82.

Organic materials with a C:N ratio ranging from about 85:1 to about 10:1 were submitted to nitrification tests in an acid and in an alkaline soil during a period of 6 months. In the acid soil only pea pod meal, with a C:N ratio of 13.3:1 showed an increase in inorganic N over control; in the alkaline soil the limit above which no nitrification will occur within a period of 6 months was at C:N = 26:1; below this limit the rate of nitrification increased rapidly, with decreasing C:N ratio. Unnitrified N was left behind in a quantity corresponding to 1.5-2.2 per cent. of the original material, the percentage being higher in the case of materials rich in N.

All the materials tended to increase the content of "α humus" in the soil, though not to the same extent or in the same manner. More "α humus" was produced in the alkaline than in the acid soil, except in the case of farmyard manure. Straw, sweet clover, lupin and farmyard manure apparently acted both through their lignin content and through the synthesising action of micro-organisms, since they increased the amounts of both N and methoxyl in humus. Mycelium of *Polyporus* contains a fraction possessing the properties of "humic acid," rich in N, but devoid of methoxyl, which persists in the soil.

The experiments show that the carbon-nitrogen ratio is a factor which exerts an influence on nitrification as profound as that of soil reaction, and that the less complete utilisation of farmyard manure nitrogen as compared with nitrogen in artificial fertilisers can to a large extent be explained hereby.

LIII. P. H. H. GRAY. *"The Formation of Indigotin from Indol by Soil Bacteria."* Proceedings of the Royal Society (B), 1928. Vol. CII., pp. 263-280.

A study of the physiology and biochemistry of new species of soil bacteria that decompose the toxic compound indol, with especial reference to the action of *Pseudomonas indoloxidans*. The indol is converted rapidly into the insoluble indigotin; for this

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reaction the organism needs a source of energy such as amino-acids, dextrose, glycerol, fatty acids, or alcohols. The conversion is effected quantitatively and appears to be carried out by means of an extra-cellular enzyme.

LIV. P. H. H. Gray and H. G. Thornton. *"The Estimation of Bacterial Numbers in Soil by Direct Counts from Stained Films."* "Nature," 1928. Vol. CXXII., pp. 140-141.

A preliminary note concerning a new method of counting soil bacteria by direct observation through the microscope.

(*b*) Protozoa.

LV. D. Ward Cutler and A. Dixon. *"The Effect of Soil Storage and Water Content on the Protozoan Population."* Annals of Applied Biology, 1927. Vol. XIV., pp. 247-254.

Stored soil is a suitable medium for experiments on micro-organisms provided that the ratio of surface to volume is relatively high. The water content of soil, if sufficiently low (1/6 to 1/5 the water-holding capacity) may act as a limiting factor for soil protozoa, but above this amount changes in the water content are without effect.

LVI. C. E. Skinner. *"The Effect of Protozoa and Fungi on Certain Biochemical Processes when Inoculated into Partially Sterilised Soil."* Soil Science 1927. Vol. XXIV., pp. 149-161.

In partially sterilised soils inoculated with bacteria *Hartmanella hyalina* and with bacteria alone, the presence of the amoebae caused a reduction in the bacterial numbers and a slight depression in carbon dioxide production and ammonia accumulation. The presence of *Trichoderma köningi* and *Penicillium* sp. increased carbon dioxide production but decreased the accumulation of ammonia.

LVII. D. Ward Cutler and L. M. Crump. *"The Qualitative and Quantitative Effects of Food on the Growth of a Soil Amoeba (Hartmanella hyalina)."* British Journal of Experimental Biology, 1927. Vol. V., pp. 155-165.

The reproductive rate in *Hartmanella hyalina* varied directly with the available bacterial food supply. It is shown that three species of soil bacteria have different feeding values both in respect of the rate of division of the amoebae, and also of the total increase in protoplasm.

LVIII. A. Dixon. *"The Effect of Phenol, Carbon Bisulphide and Heat on Soil Protozoa."* Annals of Applied Biology, 1928. Vol. XV., pp. 110-119.

Phenol has a greater lethal effect than has carbon bisulphide upon protozoa. Steaming glasshouse soil destroys the majority of protozoa and depresses their numbers for a considerable period of time.

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LIX. H. SANDON. *"A Note on the Microbiology of Wicken Fen Soils with Special Reference to the Protozoa."* Natural History of Wicken Fen, 1928. Part IV., Section 35, pp. 366-370.

In connection with the ecological survey of Wicken Fen, Cambridge, eight samples of peat soils were examined. The protozoa found in them are recorded together with the results of counts of bacteria and of actinomycetes. The rôle of micro-organisms in fen soils is briefly discussed.

LX. H. SANDON. *"A Study of the Protozoa of some American Soils."* Soil Science, 1928. Vol. XXV., pp. 107-122.

Protozoa and other micro-organisms were counted in a number of soil samples from the experimental plots at the New Jersey Experiment Station. Wide variations were found in samples taken at different dates but, on the whole, numbers were low compared with those obtained from similar plots at Rothamsted. A neighbouring soil (Penn loam) gave much higher figures. Considerable numbers of protozoa were present even during severe frost, but rapid increases occurred after thawing and the numbers then reached were much higher than at other times in the year. Counts were also made on dry, irrigated and alkaline soils at Logan, Utah, and some degree of activity was indicated in them all.

The kinds of protozoa are very similar in all soils so far examined, and their numbers are roughly proportional to the numbers of bacteria present.

(*c*) FUNGI.

LXI. W. B. BRIERLEY, S. T. JEWSON AND M. BRIERLEY. *"The Quantitative Study of Soil Fungi."* Proceedings and Papers of the First International Congress of Soil Science, 1927. Vol. III., pp. 1-24.

A summary of investigations on the quantitative estimation of soil fungi. The plating technique is divided into its component factors :—(A)Factors of Sampling : (1) methods of sampling, (2) amount of sample, (3) depth distribution of fungi in relation to sampling, (4) storage of samples, (5) comparison of samples ; (B) Factors of Suspension : (1) sampling of sample for primary suspension, (2) shape of container, (3) suspension liquid ; (C) Factors of Disintegration : (1) method of disintegration, (2) violence and duration of shaking ; (D) Factors of Dilution : (1) method of dilution, (2) degree of dilution ; (E) Factors of Plating : (1) method of plating, (2) number of plates, (3) size of plates, (4) amount of medium, (5) composition of medium, (6) acidity of medium, (7) competition on plates; (F) Factors of Incubation : (1) period of incubation, (2) temperature of incubation ; (G) Factors of Counting : (1) method of counting. These factors are studied independently and in combination and it is shown that if they are rigidly standardised a technique is obtained which gives a satisfactory degree of accuracy in replication experiments.

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LXII. E. McLennan. *"The Growth of Fungi in Soil."* Annals of Applied Biology, 1928. Vol. XV., pp. 95-109.

Sterile soil was inoculated with a known quantity of spores of four different fungi, incubated at 9° C. and at intervals representative samples were plated out by the dilution method and an analysis of the plate population made. Results showed that high plate counts were not in any way connected with vegetative growth and supported Conn's idea that in such a case one is simply measuring the sporing capacity of the forms used.

Samples of moist soil and of soil which had been dried in a vacuum desiccator over calcium chloride were plated out by the dilution method and the number of fungal colonies per plate compared. A marked decrease was noted with the dried sample. The reduced pressure was found to have no effect as drying under ordinary air-pressure gave comparable results.

Suspensions in soil, and in sand, of fragmented mycelia and of a mixture of fungal spores, were in turn plated out directly and after drying. No colonies developed from the sample in the desiccator containing only mycelia, whereas the sample containing spores was in no way affected. It is suggested therefore that the decrease obtained after drying is due to the desiccation of the vegetative mycelium in the soil and since the reduction in the number of colonies per plate is very pronounced after this treatment, it is thought that the normal fungal constituents of the soil are present extensively in the mycelial condition.

(*d*) Algæ.

LXIII. B. M. Bristol Roach. *"On the Algæ of some Normal English Soils."* Journal of Agricultural Science, 1927. Vol. XVII., pp. 563-588.

An account of an investigation of the algal-flora of four English soils by means of dilution cultures of freshly gathered samples of soil from the top, second, fourth, sixth and twelfth inch depths and from the top 6in. mixed. A counting method is described applicable to the green algæ and diatoms, by means of which it is shown that these algæ are distributed throughout the top 12in. of soil, though at the sixth and twelfth inch depths they are considerably less numerous than nearer the surface. At the fourth inch depth the numbers of individuals are not significantly smaller than on the surface and may be even greater.

The unmanured plot of Broadbalk wheat field was found to contain the same main species as the adjacent farmyard manure plot, but was poorer in number of individuals. Thirty-five species are described from each plot; they seem to be divisible into two groups, the true soil forms and casual species. Of the true soil forms some grow equally well on the surface and in the lower layers, whereas others are more numerous on the surface than within the soil. The same main types were also obtained from Barnfield and from a cottage garden, but the blue-green species were less conspicuous in both of these soils.

Experimental evidence is given to show that many of the

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algæ of the soil exist in a vegetative condition rather than a resting condition. Biological notes are made on some of the more important or interesting soil species.

LXIV. B. M. Bristol Roach. *"On the Carbon Nutrition of some Algæ Isolated from Soil."* Annals of Botany, 1927. Vol. XLI., pp. 509-517.

An account is given of the growth, both in daylight and in complete darkness, of five species of soil algæ, isolated in pure culture, on media containing mineral salts enriched with various sugars. It is shown that all five species are capable of growing in complete darkness, provided that a suitable organic compound is present in the medium, and may therefore be regarded as true soil algæ, but that the five species react quite differently to the conditions imposed upon them, and that they vary considerably in the extent to which they are able to grow in the dark. It is concluded that it is not justifiable to regard the soil algæ as a homogeneous physiological unit in considering the relation which these organisms bear to the problems of soil fertility.

LXV. B. M. Bristol Roach. *"On the Influence of Light and of Glucose on the Growth of a Soil Alga."* Annals of Botany, 1928. Vol. XLII., pp. 317-345.

Scenedesmus costulatus, Chod., var. chlorelloides, Bristol Roach, grows in liquid cultures at different rates according to the external conditions imposed upon it, and there appears to be some internal factor which limits the growth of the organism at a temperature of 24.5° C. to a maximum rate in the light represented by the figure 0.47-0.475. The maximum rate of growth is realised under purely photosynthetic conditions with a comparatively strong light intensity, and the addition of glucose to the medium produces no significant increase.

As the light intensity diminishes and the rate of growth by means of photosynthesis becomes less, the alga absorbs glucose directly from the medium to supply the deficiency due to retarded photosynthesis, but only in such quantity as will bring the total growth rate up to the maximum figure. As the intensity of the light continues to diminish, the alga absorbs increasing amounts of glucose up to a maximum quantity, which is approximately equivalent to the amount assimilable when the alga is grown in complete darkness with glucose as its sole source of carbon.

With light of low intensity, when the rate of growth due to photosynthesis is low, the total rate of growth of the alga possible in a glucose medium is equal to the sum of the rates due to photosynthesis alone and to the maximum amount of glucose assimilable in the dark.

With low and moderate intensity of illumination, the rate of increase of the growth rate in a mineral salts medium due to photosynthesis alone appears to be directly proportional to the rate of increase in light intensity, until a certain illumination of optimum efficiency is reached; beyond this optimum successive increases in light produce progressively smaller increments in growth rate as the alga approaches more clearly to its maximum rate of growth.

LXVI. B. M. Bristol Roach. *"The Present Position of our Knowledge of the Distribution and Functions of Algæ in the Soil."* Proceedings and Papers of the First International Congress of Soil Science, 1927. Vol. III., pp. 1-9.

A summary: special attention is given to the distribution of algæ in the soil, to methods for distinguishing between resting and vegetative cells, to the carbon nutrition of soil algæ and to the nitrogen cycle in the soil.

(*e*) Insects.

LXVII. H. M. Morris. *"The Insect and other Invertebrate Fauna of Arable Land at Rothamsted, Part II."* Annals of Applied Biology. Vol. XIV., 1927, pp. 442-464.

Samples of soil were taken from six of the plots of Barn Field on the farm of the Rothamsted Experimental Station, and insects and other invertebrates found therein are recorded together with the approximate depth at which they occurred. Of these plots one receives no manure, one superphosphate only and one ammonium salts only, while of the other three, all of which receive dung, one receives superphosphate and potash, and another ammonium salts in addition. The total number of insects and other invertebrates per acre in the undunged plots were 1,208,000, 1,410,000 and 1,734,000 respectively. Of these, 673,000, 999,000 and 1,424,000 respectively were insects. Similarly in the dunged plots the total numbers of insects and other invertebrates per acre were 12,948,000, 9,448,000 and 10,516,000 respectively, and of these 2,323,000, 2,215,000 and 4,677,000 respectively were insects. Each sample was taken in five layers so that it was possible to record the approximate depth at which each individual occurred. The greatest number, both of insects and of other invertebrates, occurred in the upper five inches of the soil. It appears that artificial manures have little or no effect on the soil fauna, while the effect of dung in increasing the fauna is very considerable.

V.—THE PLANT IN DISEASE; CONTROL OF DISEASE.

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

(*a*) Insect Pests and their Control.

LXVIII. H. F. Barnes. *"The British Gall Midges of Peas."* Bulletin of Entomological Research, 1928. Vol. XIX., pp. 183-185.

In Britain three species of gall midges exist whose larvæ may be found in pea pods: the pea midge, *Contarinia pisi*, which is the most common and is sometimes a pest; *Lestodiplosis pisi*, a predator on the former; and *Clinodiplosis pisicola*, an inquiline. The larvæ of these three species are discussed and the last-named midge is described in detail for the first time.

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LXIX. H. F. BARNES. *" Wheat Blossom Midges (Cecidomyidæ, Diptera). Differences between ' Contarinia tritici ' (Kirby) and ' Sitodiplosis mosellana ' (Gehin)."* Bulletin of Entomological Research, 1928. Vol. XVIII., pp. 285-288.

In the past, wherever Cecidomyid larvæ have been found in the ears of wheat, the presumption has been that the species concerned was *C. tritici* : this error has been made both in England and North America. It is shown that in the vast number of cases of infection the species concerned is *S. mosellana,* which attacks the kernel and not the anthers as in *triciti.* Full descriptions and figures are given for separating the two species in question.

LXX. J. DAVIDSON. *" On Some Aphides infesting Tulips."* Bulletin of Entomological Research, XVIII., Sept., 1927, pp. 51-62.

A detailed technical description is given of three species of aphids obtained from various sources on tulip bulbs and iris corms. These species were reared and observations made on the progress of infestation on tulips. *Anuraphis tulipæ* is shown to be a serious pest of stored bulbs, and when the latter are grown early in the season in glasshouses, multiplication becomes rapid on the growing leaf-spathes which leads to distortion of the plants. The other species, viz., *Rhopalosiphoninus tulipælla* and *Macrosiphum gei* are of less importance : the first mentioned along with *Anuraphis tulipæ* have up to the present been imperfectly known and detailed figures illustrating their distinctive characters given. Infested stored bulbs should be collected and subjected to treatment in order to prevent widespread infection of other bulbs in the same store and various methods of treatment are given.

LXXI. J. DAVIDSON. *" On the Occurrence of the Parthenogenetic and Sexual Forms in Aphis rumicis, with Special Reference to the Influence of Environmental Factors."* Annals of Applied Biology, 1929. Vol. XVI., pp. 104-134.

This Paper discusses in detail experimental evidence as to the factors which tend to the production of alate dispersal forms, apteræ and sexuales. Especially notable are the effects of overcrowding on the host plant leading to the production of alate forms : the effects of removal of the growing points of bean plants on the degree of infestation of the latter by the aphids : and the effects of duration of daylight and temperature on the incidence of the sexual forms.

LXXII. W. M. DAVIES. *" The Effect of Variation in Relative Humidity on Certain Species of Collembola."* British Journal of Experimental Biology, 1928. Vol. VI., pp. 79-86.

It was found that, with the exception of the genus *Entomobrya,* Collembola devoid of a tracheal system, are very susceptible to atmospheric dryness. Species which possess a tracheal system

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are capable of withstanding complete dryness for a period of 10 hours or double the maximum time found for non-tracheate forms. The influence of variation in relative humidity in the death-rate of various species has been studied, and at a uniform temperature of 25° C. a saturated atmosphere was found necessary for survival. The work has a definite practical bearing, since it explains why methods of controlling *Bourletiella hortensis* require to be carried out in early morning or after heavy rain during the day : at other times this insect retreats below the soil.

LXXIII. W. M. Davies. *" The Bionomics of Apion ulicis (Gorse Weevil) with Special Reference to its Rôle in the Control of Ulex europæus in New Zealand."* Annals of Applied Biology, 1928. Vol. XV., pp. 263-286.

The external morphology of this species in its different stages is described and the details of its biology and feeding habits are given. The effects of the feeding of the adults and larvæ on the host plant are described, together with tabular results of a study of pod infection from samples taken from 62 districts in Great Britain. As high as 92 per cent. infection was observed in some cases. Prolonged tests were carried out with respect to the possibility of the *Apion* attacking cultivated leguminous plants, but gave negative results. The species is considered valuable for the purpose of attempting the control of the spread of gorse in New Zealand and shipments have been made to that country for this purpose.

LXXIV. F. Tattersfield and C. T. Gimingham. *" Studies on Contact Insecticides, Part V. The Toxicity of the Amines and N-Heterocyclic Compounds to ' Aphis Rumicis L '."* Annals of Applied Biology, 1927. Vol. XIV., pp. 217-239.

The toxicities to *Aphis rumicis* of certain alipathic and aromatic amines and of some of the simpler nitrogen-heterocyclic derivatives have been quantitatively determined.

Tetramethylammonium hydrate and chloride are more toxic than the corresponding tetraethylammonium compounds. This is in keeping with the findings of Dale and his co-workers, who have shown that tetramethylammonium has certain physiological effects similar to those of nicotine, which are not shown by tetraethylammonium.

The aromatic amines, on the whole, show little insecticidal action. Aniline and most of the aliphatic anilines are only slightly toxic to *A. rumicis*. The substitution of aromatic groups in the amino group of aniline increases toxicity more than the substitution of aliphatic groups. There are interesting relationships in regard to toxicity among these compounds.

o-Nitraniline is one of the most toxic of the aniline derivatives.

Among the heterocyclic compounds, nicotine is highly poisonous to *A. rumicis*. The heterocyclic rings constituting the molecule of nicotine are much less toxic than nicotine itself; pyrrole and pyridine show comparatively slight insecticidal action. The

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order of increasing toxicity of the simpler N-heterocyclic compounds is pyrrole, pyridine, picoline, lutidine, quinoline and isoquinoline, acridine.

Hydrogenation of pyridine and pyrrole increases their toxicity, piperidine is more toxic than pyridine and pyrrolidine than pyrrole.

Benzyl-pyridine is the most toxic pyridine derivative tested.

LXXV. F. TATTERSFIELD AND C. T. GIMINGHAM. *"Studies on Contact Insecticides, Part VI. The Insecticidal Action of the Fatty Acids, their Methyl Esters and Sodium and Ammonium Salts."* Annals of Applied Biology, 1927. Vol. XIV., pp. 331-358.

The toxicities to *Aphis rumicis L.* of the fatty acids from formic to stearic and of the sodium and ammonium salts and methyl esters, applied as spray fluids, have been quantitatively determined. Two unsaturated acids, undecenoic and oleic, are included.

There is a rise in toxicity of the acids with increase of molecular weight as the series is ascended from acetic to undecylic acid. Formic acid is exceptional. Beyond undecylic acid, there is a fall in toxicity, and acids higher in the series than tridecylic, show only slight toxic action.

The sodium salts of the fatty acids are in most cases much less toxic than the corresponding acids, though the difference is less marked with the higher acids. Oleic acid and sodium oleate are of the same order of toxicity.

The ammonium salts are generally less toxic than the corresponding acids, but the differences are much less than in the case of the sodium salts. With some of the higher acids, *e.g.*, myristic and oleic, neutralisation with ammonia increases toxicity. The relatively high toxicity of the ammonium salts may be due, at least partly to liberation, by hydrolysis, of free fatty acid in a very finely divided state.

Methylation of the fatty acids reduces toxicity; all the methyl esters are less toxic than the acids or ammonium salts.

Both the ammonium salts and the methyl esters show, like the acids themselves, increase of toxicity with increase of molecular weight up to a certain point. The formates are exceptional.

The fatty acids do not show marked toxicity to the eggs of *Selenia tetralunaria* Hüfn. at concentration below 2 per cent.

Possible relationships between certain physical properties (physical state, volatility, dissociation constants, partition coefficients and surface tension) of the fatty acids and their insecticidal action are discussed.

Determination of partition coefficients as between olive oil and water and comparison of the figures with the relative toxicities show a steady rise in toxicity with a decrease in the partition coefficients (water/oil) from acetic to capric acid. Formic acid is again exceptional. With lauric and oleic acids there is a break in correlation. The bearing of the solubility relationships of the acids on these results is considered.

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LXXVI. F. TATTERSFIELD. *"The Relationship between the Chemical Constitution of Organic Compounds and their Toxicity to Insects."* Journal of Agricultural Science, 1927. Vol. XVII., pp. 181-208.

An analysis is made of the relationships between chemical constitution and insecticidal action in the vapour phase. There is rough correlation between the molecular weights and volatilities of organic compounds and toxicity, but it is probable that these relationships are only indirectly involved and that they indicate a connection of a more direct kind with some other property such as adsorption.

An account is given of the toxicity to insects of certain plant products. The most potent of these are certain tropical leguminous plants used as fish-poisons. A brief account is given of the chemical derivatives found in these plants. One of them, "tubatoxin," is one of the most potent contact insecticides known.

A list of the groups of organic chemicals tested for their toxic action on *Aphis rumicis* and the eggs of *Selenia tetralunaria* is given. A more detailed account is given for each group of the relationships between chemical constitution and insecticidal action. It is shown that the substitution of certain radicals in the benzene ring profoundly affects toxicity, but that toxic action depends not only upon the radicals, but the number substituted and, in certain cases upon their relative position.

An analysis is made of the bearing of certain of the physical properties of these acids upon toxicity; such are volatility, physical state, partition coefficients, dissociation constants and surface tensions of their solutions in water. None of these properties entirely accounts for the toxicities shown by the fatty acids, but to a certain extent with some of them correlation is sufficiently close to indicate the necessity of further study but on simplified lines.

LXXVII. F. TATTERSFIELD. *"The Decomposition of Naphthalene in the Soil and the Effect upon its Insecticidal Action."* Annals of Applied Biology, 1928. Vol. XV., pp. 57-80.

When naphthalene is incorporated thoroughly with soil, it shows a fairly potent toxic action on wireworms; uneven distribution lessens its efficiency as, owing to its low vapour pressure and consequent slow, spread, it produces only a small zone of toxic action.

The persistence of the toxic action depends upon the soil type. In soils rich in organic matter, toxicity disappears more rapidly than in soils less rich in organic matter. Toxicity persists longer in sterile soils and in sand than in unsterilised soils, and in dry than in moist soils.

The rate of disappearance of naphthalene from soil has been determined. It depends very little upon volatilisation, but almost entirely upon some factor inherent in the soil, which is more active in soils rich in organic matter than those poor in organic matter, and in unsterilised soils than in sterile soils.

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The bacterial numbers of the soils are at first decreased by the addition of naphthalene, but there is a rapid rise during the period when acceleration in the rate of decomposition of the naphthalene is taking place. All the evidence indicates that the loss of naphthalene from the soil is mainly due to bacterial decomposition.

Methods of estimating naphthalene are described. They depend on formation of naphthalene picrate. Picric acid can be more readily titrated by alkali in orange and yellow coloured light than in white light.

LXXVIII. J. C. F. Fryer, F. Tattersfield and C. T. Gimingham. *"English-grown Pyrethrum as an Insecticide, I."* Annals of Applied Biology, 1928. Vol. XV., pp. 423-445.

The toxicity to *Aphis rumicis L.* and to certain caterpillars of spray fluids prepared from samples of pyrethrum (*Chrysanthemum cinerariæfolium*) grown in England from Swiss and Japanese seed, have been quantitatively determined.

Pyrethrum flowers, grown in six different localities, showed only slight differences, and, for practical purposes, all the samples had approximately the same toxicity. They did not differ in this respect significantly from a sample grown on the continent.

The toxicities of extracts of equal weights of pyrethrum flowers tested at different stages of development differed very little. Artificial drying of the flowers had no significant effect on the toxic properties. The flowers were about ten times as toxic as the stalks, weight for weight. Prolonged exposure of pyrethrum to wet conditions led to some loss of toxicity, but contrary to the usual opinion, if stored in a reasonable manner, it remained for long periods without deterioration. Caterpillars of different species showed marked differences in susceptibility to the action of pyrethrum. The biological method employed has proved suitable for evaluating samples of pyrethrum.

LXXIX. C. T. Gimingham and F. Tattersfield. *"Laboratory Experiments with Non-arsenical Insecticides for Biting Insects."* Annals of Applied Biology, 1928. Vol. XV., pp. 649-658.

A convenient technique for experiments with insecticides for biting insects is described.

The silicofluorides of sodium, potassium, aluminium and calcium, used in the form of spray-fluids, showed considerable toxicity to young larvæ of several species of moths. The degree of resistance varies with different species and is greater with older larvæ. Considerable, but irregular, injury to foliage was noted, and much further work is required to establish the conditions under which these compounds could be safely used.

Foliage sprayed with extracts of certain tropical plants is extremely repellent to young larvæ. Even with high dilutions of the extracts, the foliage remained uneaten, and the larvæ eventually died of starvation.

A short review of some recent work on laboratory experiments with non-arsenical insecticides for biting insects is given.

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LXXX. F. TATTERSFIELD, R. P. HOBSON AND C. T. GIMINGHAM. *" Pyrethrin I. and II. Their Insecticidal Value and Estimation in Pyrethrum (' C. cinerariæfolium ') I."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 266-296.

Pyrethrin I. and II. have been isolated by the method of Staudinger and Ruzicka from the insecticidal plant Pyrethrum (*Chrysanthemum cinerariæfolium*). Both are shown to be highly toxic to the insect *A. rumicis*.

Pyrethrin I. was found to be the most toxic substance so far tested by us and it was about ten times as toxic to these insects as pyrethrin II., it is concluded that it is mainly responsible for the insecticidal value of pyrethrum.

Two micro-analytical methods of determining the pyrethrin content are described : (*a*) by means of the acids after hydrolysis ; (*b*) by means of the semicarbazone.

The analytical results are obtained for a series of pyrethrum samples agreed with their observed insecticidal properties.

Comparisons of the pyrethrin contents, as estimated, with the results of direct toxicity experiments both on the pyrethrum samples and the pure pyrethrins, confirm the validity of the analytical methods.

LXXXI. F. TATTERSFIELD AND R. P. HOBSON. *" Pyrethrin I. and II. Their Estimation in Pyrethrum (' Chrysanthemum cinerariæfolium ') II."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 433-437.

The analytical method previously described is found applicable to flowers grown from Japanese seed. A short analytical method for evaluation is described.

(*b*) FUNGUS PESTS AND THEIR CONTROL.

LXXXII. S. DICKINSON. *" Experiments on the Physiology and Genetics of the Smut Fungi.-Seedling Infection."* Proceedings of the Royal Society (B), 1927. Vol. CII., pp. 174-176.

The apparatus devised by the author (see 1925-1926 Report, Paper No. LXXII.) for isolating individual spores from a culture has made possible the present investigation. The results show that no infection of oat or barley seedlings by pure cultures of smut fungi occurs when one gender (sex) is present, but when, under similar conditions, two genders are present, 90 per cent. infection and over is obtained.

LXXXIII. S. DICKINSON. *" Experiments on the Physiology and Genetics of the Smut Fungi. Cultural Characters, Part I. Their Permanence and Segregation."* Proceedings of the Royal Society of London, 1928. Series B, Vol. CIII., pp. 547-555.

The Smut Fungus used in the experiments described is the Covered Smut of Oats (*Ustilago levis*). After isolating a chlamydospore and allowing it to germinate on a suitable medium, the

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first sporidium formed by each of the four segments of its promycelium was isolated, transferred to test-tube slopes, and allowed to develop in culture. Four cultures of strains were in this way obtained from one chlamydospore. This has been repeated with a number of chlamydospores of known parentage.

The strain obtained from any one of these isolated sporidia was found to differ in one or more cultural characters from the other three strains arising from the same chlamydospore. A brief description of certain of these cultural characters is given.

The segregation of these cultural characters was found to be on a 2 :2, 3 :1 and 4 :0 basis. It is deduced that this segregation may take place in either the first or the second of the " reduction divisions." So far the segregation of any one character was found to be independent of that of any other.

No conclusive evidence of somatic segregation has up to the present been obtained, the strains remaining constant during the time they have been in culture. The cytoplasm has been shown to have no determining influence on the cultural characters so far described.

LXXXIV. W. A. Roach. *" Immunity of Potato Varieties from Attack by the Wart Disease Fungus, ' Synchytrium endobioticum ' (Schilb.) Perc."* Annals of Applied Biology, 1927. Vol. XIV., pp. 181-192.

The present investigation is an attempt to determine, by grafting together pieces of immune and susceptible plants, whether the cause of immunity from wart disease of potatoes is carried by chemical compounds which can traverse unchanged a graft fusion layer or by those which are unable to do so.

For this purpose all the eight possible types of plants have been built up by grafting together root, shoot and tuber systems from either immune or susceptible plants.

In none of these experiments was the reaction of the tubers towards wart disease changed; hence the cause of the immunity is probably not carried by any compound which is able to traverse the plant, and the problem is thus considerably narrowed down. Examination of the proteins from immune and susceptible varieties by immuno-chemical methods is a hopeful future line of attack.

LXXXV. W. A. Roach and Mary D. Glynne. *" The Toxicity of Certain Sulphur Compounds to Synchytrium endobioticum, the Fungus causing Wart Disease of Potatoes."* Annals of Applied Biology. 1928. Vol. XV., pp. 168-189.

The toxicities towards the winter sporangia of *Synchytrium endobioticum* of certain of the simpler sulphur compounds which are at all likely to be formed when sulphur is added to soil were tested and compared with that of sulphuric acid. Sulphuric (H_2SO_4), sulphurous (H_2SO_3), dithionic ($H_2S_2O_6$), trithionic ($H_2S_3O_6$), tetrathionic ($H_2S_4O_6$), and pentathionic ($H_2S_5O_6$) acids were toxic, and this toxicity was of the same order in each case at the same hydrogen ion concentration. Their neutral salts were non-toxic. These facts suggest that the toxicities of these acids are mainly due to their hydrogen ion concentrations.

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Acidified solutions of sodium thiosulphate ($Na_2S_2O_3$), sodium hydrosulphite ($Na_2S_2O_4$) and sodium formaldehyde sulphoxylate were about ten times as toxic as sulphuric acid.

The evidence suggests that the toxicity of these acidified solutions, in excess of that accounted for by the hydrogen ion concentration, is due to the thiosulphuric acid present in each of them. In view of the instability of some of the compounds and the length of time taken to exert their toxic action on the fungus, this conclusion must be regarded as tentative.

Of the other compounds tested sodium hydroxide was found to be a little more toxic than sulphuric acid and persulphuric acid about ten times as toxic; hydrogen peroxide, calcium polysulphide and sulphuretted hydrogen were only slightly toxic.

LXXXVI. E. M. Crowther, Mary D. Glynne and W. A. Roach. *"Sulphur Treatment of Soil and the Control of Wart Disease of Potatoes in Pot Experiments."* Annals of Applied Biology, 1927. Vol. XIV., pp. 422-427.

In a series of pot experiments on potatoes grown in an acid soil artificially infected with the wart disease fungus, treatments with sulphuric acid and various combinations of sulphur and calcium carbonate, yielding a wide range of soil reaction, gave almost complete freedom from infection when the acidity of the soil had been raised to a very high value (pH 3.4 or less).

Heavy dressings of calcium carbonate, alone or with sulphur, giving a soil reaction of pH 7.5 or more, also reduced infection.

The fact that partial and even, in one experiment, complete suppression of disease was obtained at lower acidities, where the effects on the disease was not closely related to the degree of acidity, supports the tentative conclusion already drawn from field experiments that sulphur, in controlling wart disease, does not depend entirely on its effect in raising the acidity, but has also some other mode of action. Whether this toxicity which sulphur exerts apart from its effect on the acidity can be enhanced sufficiently to be of any practical value requires further investigation.

(*c*) Bacterial Diseases.

LXXXVII. R. H. Stoughton. *"The Influence of Environmental Conditions on the Development of the Angular Leaf-Spot Disease of Cotton."* Annals of Applied Biology, 1928. Vol. XV., pp. 333-341.

The serious disease of cotton caused by *Bacterium malvacearum E.F.S.*, is associated with unfavourable climatic conditions. An apparatus has been devised for controlling air temperature and humidity within a chamber. It has been found that the limiting air temperature at humidities above 80 per cent. relative saturation for secondary attack by the disease is 32° C. above which infection does not occur. At 70 per cent. relative humidity, infection is slight at 25° C. At lower humidities, no infection occurs at a temperature of 28° C.

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LXXXVIII. R. H. STOUGHTON. *"A Method of Maintaining Constant Humidity in Closed Chambers."* Journal of Scientific Instruments, 1928. Vol. V., pp. 365-366.

The instrument depends for its action on the vaporisation of water from muslin covering a carbon filament resistance lamp enclosed in a tin through which a stream of air is blown, and controlled by a hair hygrostat within the chamber.

(*d*) VIRUS DISEASES.

LXXXIX. J. HENDERSON SMITH. *"Experiments with a Mosaic Disease of Tomato."* Annals of Applied Biology, 1928. Vol. XV., pp. 155-167.

A description is given of a mosaic disease produced in tomato by a virus, possibly identical with Johnson's Tobacco Virus 6, which differs from that of ordinary tomato mosaic in the brilliance and intensity of its leaf-symptoms, but in other respects is indistinguishable from it by the characters investigated.

The filtered juice of infected plants transmits the disease in dilutions in water up to 1 in 10,000, retains its activity for a year or more at room temperature, and withstands heating for 10 minutes at 80° C., but is inactivated at 90° C.

It is not inactivated by alcohol up to 90 per cent. The virus comes down with the precipitate, and is not destroyed when the formation of precipitate is prevented by the addition of NaOH.

Attempts at cultivation of the virus outside the living plant are described; all were unsuccessful. The methods employed in filtration, inoculation, etc., are given in detail.

XC. J. HENDERSON SMITH. *"The Transmission of Potato Mosaic to Tomato."* Annals of Applied Biology, 1928. Vol. XV., pp. 517-528.

Inoculation by leaf-mutilation with the foliage of normal potatoes produced no disease in tomato. Nine varieties of potato were tested.

Similar inoculation with foliage of mosaic potatoes produced a characteristic disease in tomato. Five varieties of potato were used, of which three had been tested in the experiments with normal foliage.

The characters of the disease are described. It is transmissible back to potato again and to other solanaceous plants. The virus is filterable, is still infectious after high dilution of the extracted juice, and remains active on keeping for several months. It is less resistant to heat and alcohol than ordinary tobacco mosaic.

The disease resembles closely the spot-necrosis disease described by Johnson as obtained by inoculation of tobacco with foliage of normal potatoes, the chief difference being the greater resistance of the potato mosaics here described.

It is probable that there exist several strains, differing in resistance, of the virus causing mosaic in the potato.

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