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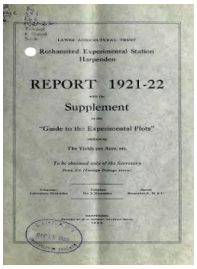
Report 1921-22 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



Full Table of Content

Summary of Papers Published - I. Scientific Papers

Rothamsted Research

Rothamsted Research (1923) *Summary of Papers Published - I. Scientific Papers ;* Report 1921-22 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 29 - 51 **- DOI: https://doi.org/10.23637/ERADOC-1-110**

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PUBLICATIONS DURING THE YEARS 1921-22.

SCIENTIFIC PAPERS.

CROPS AND PLANT GROWTH.

I. WINIFRED E. BRENCHLEY. *"Effect of Weight of Seed upon the Resulting Crop."* Annals of Applied Biology, 1923. Vol. X. pp. 223-240.

Experiments were carried out in water cultures with peas and barley, in which the competitive factors were eliminated as far as possible in order that the results could be more closely correlated with the initial weights of the seeds.

The chief results are as follows :—

1.—There is a steady and considerable rise in the dry weight of the plants as the initial weight of the seed increases. This occurs with both a limited and an abundant food supply.

2.—The efficiency index (rate per cent. increase per day) falls gradually as the weight of the seed rises. With prolonged periods of growth this tends ultimately to counter-balance the initial advantage gained by plants from the heavier seeds, but with annual crops as cereals, roots, peas, etc., harvesting occurs before this equilibrium is reached, leaving the advantage with the heavier seeds.

3.—The relative development of shoot and root is to some extent influenced by the initial weight of the seed, but may vary with the species and with the amount of available food.

4.—The results lend support to the growing agricultural practice of advocating the use of large heavy seed, especially with annual crops. The advantage in the case of perennials would appear to be less, if any, but this has not been determined by laboratory experiments.

II. WINIFRED E. BRENCHLEY, assisted by KHARAK SINGH. *"Effect of High Root Temperature and Excessive Insolation upon Growth."* Annals of Applied Biology, 1922. Vol. IX. pp. 197-209.

When similar water culture experiments are repeated at different seasons of the year and under different environmental conditions, certain variations in result occur which appear to be associated with the temperature of the nutrient solution in which the roots are immersed. Under ordinary environmental conditions of temperature and sunlight the growth of peas, as of barley, is seriously hindered by overcrowding, even when each plant receives a similar supply of food and water. Not only is less dry weight produced, but the pods become thin and distorted, and fail to develop their seeds properly.

Growth tends to be depressed in hot sunny weather when no protection is afforded. The chief detrimental factors concerned appear to be high temperatures at the roots, acting together with strong and prolonged sunshine, though the two factors acting individually are much less harmful. Under these conditions, crowding shelters the roots from overheating and the leaves from too much sunlight, and up to a certain point crowded plants make better growth than those spaced well apart. Overcrowding,

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however, still depresses growth, probably because the light and root temperature reductions are too great.

Provided insolation is not excessive, the amount of daily fluctuation of root temperature over a total range of about 22° C. (6.7°—28.9° C.) has comparatively little influence upon growth; high maxima and low minima give similar results to low maxima and relatively high minima, provided the average mean temperatures are not too dissimilar. With high root temperature a difference in the degree of insolation or in the angle of incidence of the sun's rays may have a considerable influence on growth, a slight easing off of the solar conditions enabling much better growth to be made. With very strong sunshine, reduction of high maximum root temperatures (29° C. or above) allows of satisfactory growth when unprotected plants are rapidly killed. The inhibitory action of too high temperatures at the roots is thus clearly shown.

Nevertheless, the growth so made is less good than under more normal conditions of insolation, thus demonstrating the harmful action of too powerful sunlight, when all the root temperatures rule high.

Root temperatures appear to be of greater importance than atmospheric temperatures, as good growth can be made in hot atmospheres, provided the roots are kept relatively cool. There is some reason to believe that the minima are of as much importance as the maxima, *i.e.*, that plants can withstand very high maximum temperatures provided there is a considerable drop to the minima, but cannot put up with the constant conditions of heat induced by fairly high maxima and high minima.

III. Kharak Singh. *"Development of Root System of Wheat in Different Kinds of Soils and with Different Methods of Watering."* Annals of Botany, 1922. Vol. XXXVI. pp. 353-360.

A study of the development of the root system in different kinds of soil and under varying conditions of manuring, watering, and cultivation, is of considerable importance in the Punjab (India), especially where the crops have to depend mainly on artificial irrigation. Duplicate pot experiments were carried out in which wheat plants were grown in various kinds of soil, watering being done on the surface in one case, and in the other through a small porous pot sunk to the level of the soil in the middle of each large pot, thus carrying the water directly to a lower level. The observations were preliminary in nature, but indicate that wheat plants in pots show better growth when watered from below than when watered from above. The difference is greater in light soil in the early stages of growth, but it is more marked in heavy soil in the later stages of growth.

Under the experimental conditions the development of root and shoot was best in pure sand, provided it was supplied with an adequate amount of water and was underlaid by a layer of farmyard manure. The growth of wheat is better in a mixture containing 25 per cent. sand and 75 per cent. Rothamsted soil, than in pure Rothamsted soil, or in a mixture of 50 per cent. sand and 50 per cent. Rothamsted soil. Moreover, wheat plants do not

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grow well in brick powder even when underlaid with a layer of farmyard manure.

IV. VIOLET G. JACKSON. *"Anatomical Structure of the Roots of Barley."* Annals of Botany, 1922. Vol. XXXVI. pp. 21-39.

The root system of a well-developed barley plant, whether grown in soil or water culture, consists of two types of roots : (*a*) a thin branched type, and (*b*) a thick "unbranched" type, with very abundant root hairs. The present paper embodies the results obtained from an anatomical investigation of the two types.

A branched root possesses a much thickened stele with a single large axile vessel and six to eight xylem groups, all bounded by a very thick-walled endodermis. In an "unbranched" root neither the endodermis nor the stelar tissues are thickened, the xylem groups number from twelve to sixteen, and the middle of the root consists of thin-walled pith cells traversed by four to six ducts.

The chief function of the "unbranched" roots is probably to provide the plant with a plentiful supply of water and its dissolved food, at the time when vigorous growth is setting in. This function is provided for by :—

(*a*) Abundant root hairs ;
(*b*) An increased number of large vessels and central ducts ;
(*c*) The existence of a stele composed almost entirely of thin-walled elements.

This view receives support from the fact that these roots are formed only during the early stages of the plant's vigorous growth. Researches on the development of root and shoot showed that the formation of "unbranched" roots had entirely ceased by time the plant had finished its vegetative growth and was entering on its reproductive phase. At this period of the plant's history, the nitrogen and ash constituents are migrating steadily from the straw into the grain, so that there is no need for a large root-absorbing area. On the other hand, if the "unbranched" roots functioned chiefly as buttress-roots, the plant would need them even more when the heavy grain is being formed; but that is just the time when their development ceases. Therefore the most probable function for the "unbranched" roots is to ensure a good supply of water, etc., when the plant is in a condition of strong vegetative growth.

V. KATHERINE WARINGTON. *"The Effect of Boric Acid and Borax on the Broad Bean and certain other Plants."* Annals of Botany, 1923. Vol. XXXVII. pp. 1-44.

Boron appears to have some special function in the nutrition and development of the broad bean, as this plant fails to grow satisfactorily in nutritive solution from which boron is withheld. The results of the experimental work are:—

1.—In water culture a continual supply of boric acid appears to be essential to the healthy growth of the broad bean plant, concentrations of one part of boric acid (H_3BO_3) in 12,500,000 parts—25,000 parts of nutrient solution being beneficial.

In its absence, death occurs in a characteristic manner, the apex of the shoot becoming withered and blackened. The addition of boric acid after these symptoms have set in, but before

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death finally occurs, results in a renewal of growth by means of new lateral shoots and roots. This type of dying has not been observed in broad bean plants grown in pot culture, and it is concluded that sufficient boron is present, as a trace has been detected in the soils used.

2.—The absence of boron does not cause death in barley, growth being healthy in ordinary culture solution.

3.—Excess of boric acid is poisonous to the broad bean, injury being apparent with one part of boric acid (H_3BO_3) in 5,000 parts of the water culture medium and with 0.5 gm. or 1.0 gm. per 22½ lbs. of soil in pot culture, according to the method of application.

4.—Boric acid is more poisonous to barley than to the broad bean; in water culture a concentration of one part of H_3BO_3 in 2,500,000 parts of nutrient solution, and in pot culture .5 gm. per 22½ lbs. of soil is injurious. Smaller quantities are either ineffective or slightly favourable, though the benefit is usually evident to the eye only and not shown in the dry weight.

5.—Injury is marked by (i.) retardation of germination, (ii.) first chlorosis and later brown markings of the leaves; the barley leaf becomes spotted but that of the broad bean shows a band of brown along the margins. (iii.) Retardation in maturing in the case of barley in soil culture.

6.—Preliminary experiments show that several other plants, and especially *Phaseolus multiflorus* and *Trifolium incarnatum,* appear to benefit from the addition of small quantities of boric acid to the nutrient solution, though rye, like barley, is apparently indifferent to low concentrations.

7.—Boron is found to be present in considerable quantity in the dried shoots of the broad bean plants grown in a nutrient solution containing no boron, and also in the seed. In garden-grown plants a larger proportion of boron was present in the pods than in either the stems or leaves. No more than a trace was detected in the barley seed or in the dried shoots of untreated barley grown in water culture.

8.—It is suggested that the function of boron in the case of the broad bean is probably nutritive rather than catalytic, since a supply is required throughout the life of the plant. A parallel is drawn between the action of boron on plants and the vitamines on animal life.

VI. Katherine Warington. *"The Influence of Manuring on the Weed Flora of Arable Land."* Journal of Ecology, 1924. Vol. XII.

Examinations have been made of the weed species present on the variously manured plots of fields which have been cropped continuously for a considerable period with :—

1. Winter wheat (Broadbalk Field).
2. Spring barley (Hoos Field).
3. Mangolds (Barn Field).

The data show that the chief factors which determine the dominant species are the crop and the methods of cultivation, the most important weeds being quite different in the three fields. Winter fallowing has a particularly striking influence on the weed flora.

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However, in the event of any serious deficiency such as an inadequate nitrogen supply, or a prolonged application of ammonium salts only, the influence of the manurial treatment becomes the most important factor and the flora undergoes modification of a similar nature irrespective of the methods of cultivation. In such cases a perennial type of weed, as *Equisetum arvense, Tussilago farfara* or *Cirsium arvense,* was invariably found to predominate.

Comparisons are between with the weeds recorded in 1867 on Broadbalk and Hoos fields and those found at the present day. Considerable reduction in the number of species has taken place in the former case, while changes in the individuals comprising the flora have occurred on both fields.

The distribution and relative abundance of species and individuals are also described in the case of Broadbalk field.

METHODS OF STATISTICAL EXAMINATION AND RESULTS.

STATISTICAL TREATMENT OF SMALL SAMPLES.

VII. R. A. Fisher. *"On the 'Probable Error' of a Coefficient of Correlation deduced from a small Sample."* Metron, 1921. Vol. I., No. 4. pp. 1-32.

Agricultural experiments deal almost invariably with a number of replicated plots, or parallel experiments, which is statistically small; approximate methods suitable for large samples are therefore liable to break down, and to lead to erroneous conclusions. This paper gives the exact form of distribution for correlation coefficients obtained from small samples. By changing the scale upon which the correlation is measured, correlations from small samples may be treated with accuracy, and at the same time corrected for the small bias which is introduced by the standard methods of calculation.

AGREEMENT OF THEORY AND OBSERVATION.

VIII. R. A. Fisher. *"On the Interpretation of χ^2, from Contingency Tables, and the Calculation of P."* Journal of the Royal Statistical Society, 1922. Vol. LXXXV. pp. 87-94.

Statistical tests of the agreement of series of experimental observations with any hypothesis, by which it is intended to interpret them, may be carried out by calculating the statistic χ^2, which measures the discrepancy. The distribution of χ^2, when the hypothesis tested is in fact true, can be calculated, and in this manner cases in which the discrepancy is excessive may be detected. In this paper it is shown that when the data to be tested have been used to construct the hypothetical expectation it is necessary to adopt a more severe test of agreement than that previously in use. This change of procedure, which particularly affects tests of independence in contingency tables, and of the goodness of fit of theoretical curves, may be simply and accurately effected by taking account of the number of degrees of freedom in which observations may differ from expectation, instead of merely the number of frequency classes.

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THEORY OF STATISTICAL REDUCTIONS.

IX. R. A. Fisher. *"On the Mathematical Foundations of Theoretical Statistics."* Philosophical Transactions of the Royal Society, 1922. Vol. CCXXII. pp. 309-368.

The main desideratum in the statistical reduction of data is that the statistics calculated shall include the whole of the information supplied by the data. It has been possible to put this requirement in a mathematical form, and so to lay down general conditions for the complete exhaustion of the data; in particular it is possible to ascertain for any special statistical method proposed, of what percentage of the total information available it makes use. Many such tests are applied to current statistical methods, and in particular to the estimation of the numbers of soil protozoa by the dilution method.

RAINFALL IN BRITAIN.

X. R. A. Fisher and W. A. Mackenzie. *"The Correlation of Weekly Rainfall."* Quarterly Journal of the Royal Meteorological Society, 1922. Vol. XLVIII. pp. 234-242.

To study the effects of weather on crop production by means of simultaneous crop and weather records from different parts of the country, and thereby to reduce the number of years required for the accumulation of data comparable with the existing Rothamsted records, it is necessary to know the correlation between the meteorological records of different stations. Such information is also necessary in repairing defective records from those of neighbouring stations, as also in estimating weather conditions over local areas, such as river basins. This paper is a study of records from Aberdeen, York, and Rothamsted in respect of weekly rainfall. Even Rothamsted and Aberdeen 375 miles apart show a distinct positive correlation (average value .3717) in rainfall; the intermediate station, York, 150 miles from Rothamsted, and 225 miles from Aberdeen, gives average correlations .5898 and .5275. All three comparisons show well marked annual oscillations, the rainfall being most uniform in winter and least so in the early summer. Meteorologists suggest two possible causes for this novel phenomenon: (i.) the summer prevalence of local thunderstorms, (ii.) the more northern track of the summer cyclones. Whatever its cause, it is apparent that simultaneous crop and weather observations will throw light especially on the effects of summer rain or drought.

PREDICTION FORMULÆ.

XI. R. A. Fisher. *"The Goodness of Fit of Regression Formula and the Distribution of Regression Co-efficients."* Journal of the Royal Statistical Society, 1922. Vol. LXXXV. pp. 597-612.

Statistical predictions are based upon regression formulæ, and their importance required that the correction established in Paper No. VIII. (see above) should be applied in detail to such cases. It

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was possible to find the exact distribution of the discrepancy between prediction and observation, and to render previous methods more exact in other points besides that mentioned above. In addition the true form of the distribution of the regression coefficients was established, for which approximate forms only had been previously available.

INHERITANCE CORRELATIONS.

XII. R. A. Fisher. *"On the Dominance Ratio."* Proceedings of the Royal Society of Edinburgh, 1922. Vol. XLII. pp. 321-341.

The effects of selection on the inheritance correlations show themselves in the dominance ratio. The value obtained from human measurements are all close to $\frac{1}{3}$, and this value is not readily intelligible upon the simpler theory in which the effects of selection are ignored. When selection is taken into account it is demonstrated that the dominance ration will rise to $\frac{1}{3}$, thus providing the final step necessary to bring the whole of the existing correlation measurements in mankind into harmony with the Mendelian theory of inheritance.

CROSSOVER RATIOS.

XIII. R. A. Fisher. *"The Systematic Location of Genes by means of Crossover Observations."* American Naturalist, 1922. Vol. LVI. pp. 406-411.

It is shown how the whole of the information supplied by crossover observations may be utilised in determining a consistent system of crossover ratios; the method is based upon that developed in Paper No. IX. (see above), and the working is analogous to that of a solution of least squares.

ACCURACY OF BACTERIAL COUNTING.

XIV. R. A. Fisher, H. G. Thornton, and W. A. Mackenzie. *"The Accuracy of the Plating Method of Estimating the Density of Bacterial Populations."* Annals of Applied Biology, 1922. Vol. IX. pp. 325-359.

As a rule, the accuracy of biometrical determinations must be ascertained empirically from a statistical study of the observations; in certain cases, as has been shown in the theory of hæmocytometer counts, the law of variation may be calculated, and the accuracy known with precision, provided the technique of the counting process is effectively perfect. A study of the extensive bacterial count data accumulated at Rothamsted by Cutler and Thornton, using Thornton's agar medium, indicated that the same law of variation, the Poisson series, was obeyed by the number of colonies counted on parallel plates. Statistical tests were devised which proved that, save for a small proportion of definite exceptions, the necessary perfection of technique was effectively realised. In studying the exceptional cases it appeared that these fall into two classes : (i.) an abnormally high variation which, when investigated experimentally, has been traced to certain bottom spreading organisms isolated from soil from Leeds and from Rothamsted,

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and (ii.) an abnormally low variation ascribable to defective procedure in the preparation of the medium. Application of the same tests to other extensive series of bacterial counts showed that a similar approach to theoretical accuracy, though rare, had been obtained by Breed and Stocking in counts of *B. coli* in milk. It should be emphasised that all cases of departure from the theoretical law of distribution, which have been investigated, are associated with large systematic errors in the counts; for this reason simple tests are presented by which such deviations from the theoretical accuracy of the method can be detected.

ACCURACY OF APHIS COUNTS.

XV. R. A. FISHER. *"Appendix to 'Biological Studies of* APHIS RUMICIS,' *by* J. DAVIDSON." Annals of Applied Biology, 1922. Vol. IX. pp. 142-145.

A special method was developed for determining the accuracy of Dr. Davidson's counts on Aphids; by this means it was possible to show that the 19 varieties of bean tested could be assigned to only six degrees of susceptibility to aphis infestation.

MANURIAL RESPONSE OF POTATO VARIETIES.

XVI. R. A. FISHER and W. A. MACKENZIE. *"The Manurial Response of Potato Varieties."* Journal of Agricultural Science, 1923. Vol. XIII. pp. 311-320.

In an experiment carried out at Rothamsted (1922), twelve potato varieties were each tested with six different manurial treatments, each test being triplicated. Consequently it was possible to test a question upon which very little information has hitherto been available, namely, whether different varieties respond alike to manurial treatment. It is impossible to generalise from a single test of a single species, and it has seemed to the authors of more importance to call attention to (i.) the kind of data required for such an enquiry, and (ii.) the type of statistical treatment needed to elicit an answer, than to emphasise the fact that no significant differences are observable in the manurial response, although the varieties differed much among themselves in yield, and the different treatments also resulted in large differences in yield.

SOIL ORGANISMS.

XVII. E. J. RUSSELL. *"Les Micro-Organismes du Sol dans leurs rapports avec la croissance des plantes. Position actuelle du probléme."* Ann. de la Sci. Agronomique, 1921. pp. 49-67.

A review of the present position of our knowledge on this subject.

ALGÆ.

XVIII. B. MURIEL BRISTOL and HAROLD J. PAGE. *"A Critical Enquiry into the Alleged Fixation of Atmospheric Nitrogen."* Annals of Applied Biology, 1923. Vol. X. pp. 1-30.

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Four species of green algæ were grown in pure culture on six media which had as a common basis a solution of mineral salts devised by Schramm, but differing in that the nitrogen was supplied as ammonium nitrate, calcium nitrate or ammonium sulphate; for each of these sources of nitrogen there were two media, one without added sugar and the other containing 1% glucose. The cultures were aerated daily with sterile air free from combined nitrogen. The initial nitrogen-content of the medium in each flask was ascertained from check analyses of that medium, and the nitrogen-content after six months' growth was determined by chemical analysis of the whole of the contents of the flask.

In practically all cases a good growth of algæ was obtained, and in a large number the growth was luxuriant. Nevertheless the analytical results afforded no evidence whatever that any fixation had occurred. In fact, those cultures the growth of which had been most luxuriant had a final nitrogen-content that was, if anything, slightly lower than that of the medium originally.

This result differs from that obtained by Wann (Amer. Jour. Bot., 1921., Vol. VIII.) Investigation showed, however, that the method by which he estimated nitrogen breaks down in presence of nitrate. The results give the appearance of nitrogen fixation even when none occurred.

The chemical methods used by the present authors were free from these sources of error and, as already stated, no fixation could be detected. While it is quite conceivable that green algæ might under certain conditions, as yet unknown, assimilate atmospheric nitrogen, there is so far no trustworthy evidence that they can do so.

BACTERIA.

XIX. H. G. Thornton. *"On the Development of a Standardised Agar Medium for Counting Soil Bacteria, with especial regard to the Repression of Spreading Colonies."* Annals of Applied Biology, 1922. Vol. IX. pp. 241-274.

For counting bacteria by the plating method it is a first essential to accuracy that the plating medium should give uniform results. The medium should be exactly reproducible, *i.e.*, different batches should give similar results. In the medium here developed, this has been achieved by using pure chemical compounds as food constituents, selecting those compounds that did not alter the reaction of the medium during sterilisation.

Further parallel platings of a suspension of organisms made on a single batch of medium should develop the same number of colonies (within the limits of random sampling variance). This necessitates the independent development of each colony on the plate, which on agar media is frequently prevented by the development of bacteria that form rapidly spreading colonies which interfere with the development of other bacteria.

A special study was therefore made of a common "spreading" organism with a view to limiting its growth. It was found that the organism spreads over the agar surface by active motility and that the factors controlling its spread were (i.) the existence of a

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surface film of water on the agar, and (ii.) the rate of multiplication previous to the drying of this film. In the present medium this rate of multiplication has been much reduced so that spreading colonies are greatly restricted. The medium has the following composition :—K_2HPO_4, 1.0 gram; $MgSO_4$, 7 H_2O, 0.2 grs.; $CaCl_2$, 0.1 gr.; NaCl, 0.1 gr.; $FeCl_3$, .002 grs.; KNO_3, 0.5 grs. Asparagine, 0.5 grs.; mannitol, 1.0 gram; agar, 15.0 grs.; water to 1000 cc. Reaction brought to PH 7.4 before sterilisation.

(For the rigid test of this medium, see Paper XIV., p. 35.)

PROTOZOA.

XX. D. W. CUTLER, LETTICE M. CRUMP, and H. SANDON. *"A Quantitative Investigation of the Bacterial and Protozoan Population of the Soil."* Phil. Trans. Roy. Soc., London, B., 1922. Vol. CCXI. pp. 317-350.

The results of 365 consecutive daily counts of the numbers of bacteria and of six species of protozoa in a normal field soil are given, and the methods of counting bacteria and protozoa are described.

The numbers of both bacteria and protozoa rarely remain the same from one day to the next. The fluctuations are very great, but it has not been found possible to connect them with meteorological or general soil conditions.

Fourteen-day averages of the daily numbers demonstrate that well-marked seasonal changes in the soil population are superimposed on the daily variations in numbers. In general, both bacteria and protozoa are most numerous at the end of November and fewest in February. These changes are not directly influenced by temperature or rainfall, but show a similarity to the seasonal fluctuations recorded for many acquatic organisms.

There is a slight tendency for the various species of flagellates to fluctuate together from day to day, but this is not shown by the two species of amœbæ.

An inverse relationship is found between the numbers of bacteria and active amœbæ in 86% of the total observations.

A two-day periodicity obtains for the active numbers of one species of flagellate (*Oicomonas termo*).

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

Soil sterilized by heat was inoculated with :—

(*a*) Bacteria alone;
(*b*) ,, + one species of amœba;
(*c*) ,, + one species of flagellate.

Daily bacterial counts made on each portion of soil showed that the one containing no protozoa sustained a greater number of bacteria than those containing protozoa. Also the bacteria in the protozoa free soil did not exhibit the fluctuations in numbers characteristic of soil in which protozoa were living.

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XXII. S. M. Nasir. *"Some Preliminary Investigations on the Relationship of Protozoa to Soil Fertility with Special Reference to Nitrogen Fixation."* Annals of Applied Biology, 1923. Vol. X. pp. 122-133.

A perusal of the results shows that the presence of protozoa has no depressing effect on the nitrogen-fixing bacteria, either in the artificial culture media, or in sand cultures. From a total of 36 experiments done in duplicates or triplicates, 31 showed a decided gain, while only 5 gave negative results. The average figure for fixation works out to be 8.5%, which is well above the experimental error.

The highest fixation of 36.04% was recorded in sand cultures in the case of ciliates. All the three types of protozoa gave higher fixation figures. The experiment was repeated six times, and every time concordant results were obtained.

XXIII. D. W. Cutler and Lettice M. Crump. *"The Rate of Reproduction in Artificial Culture of Colpidium Colpoda."* Biochemical Journal, 1923. Vol. XVII. pp. 174-186.

Methods are given by which it has been found possible to obtain comparable results when studying the reproductive rates of certain protozoa in mass cultures.

It is shown that within a relatively short period after inoculation, under certain conditions, a varying proportion of the organisms die; and that this is correlated with the age of the culture from which the inoculation was made.

By means of three hourly counts it was found that death occurs even during the period of maximum reproduction.

Evidence is supplied that in certain strains of Colpidium the rate of reproduction from inoculation to the maximum numbers attained is constant.

XXIV. Madeleine Perey. *"Les Protozoaires du Sol."* Ann. Sci. Agron., 1923. Vol. LXIII. pp. 333-352.

A short review is given of our knowledge of soil protozoa together with an account of the species of protozoa found in certain French soils.

XXV. H. Sandon. *"Some Protozoa from the Soils and Mosses of Spitsbergen."* Journ. Linn. Soc., 1923. Vol. XXXIV.

Samples of soils and mosses brought back from Spitsbergen by the Oxford University expedition of 1921 and 1922 were examined, and an abundant protozoal fauna, practically identical with that found in soils and mosses of temperate lands, was found. Protozoa were found to be considerably more numerous in some of the soil samples than in others, but no close connection could be found between the numbers of species present and the physical or chemical properties of the soils. Descriptions are given of seven previously undescribed flagellates, of which five, however, occur also in Rothamsted soils.

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FACTORS DETERMINING ENVIRONMENTAL CONDITIONS.

XXVI. E. J. Russell. *"The Physico-Chemical Problems relating to the Soil."* Trans. Faraday Society, 1922. Vol. XVII. pp. 219-223.

A general survey of the physico-chemical factors operating in the soil and their influence on fertility. The soil is regarded as a system formed of four components : (i.) mineral particles; being disintegrated and decomposed rock fragments which, through the action of weather, water, ice and other factors, have in course of time been reduced to dimensions varying from about 1 mm. in diameter to molecular orders of magnitude. (ii.) Colloidal material; either very fine particles or a jelly coating the larger particles and consisting of materials such as precipitated oxides of iron and aluminium, silicia, etc., or both. (iii.) Intermingled in most intimate fashion with this is the organic matter, residues of past generations of plants and animals, which represents the source of energy for the large population of soil organisms. (iv.) The soil solution, being the soil water and everything dissolved therein. The whole mass is permeated with air. It is shown that the agricultural and physical properties of the soil can to a considerable extent be explained by such a system, but there are facts which do not as yet readily fit it.

A more detailed discussion of certain aspects of the subject is given in the following three papers.

XXVII. H. J. Page. *"The Part Played by Organic Matter in the Soil System."* Trans. Faraday Society, 1922. Vol. XVII. pp. 272-287.

The influence of the humic material of the soil, on the physical and physico-chemical properties of the soil is discussed. Owing to the colloidal nature of this humic material, its chemical nature and mode of formation are still little understood. The established agricultural practice of using dung, green manures, etc., to maintain the fertility of the soil, however, depends in a large degree on the colloidal nature of the humic material derived from such organic manures; even without more knowledge of the chemical nature of humus, its effect on tilth, moisture relationships, supply of plant nutrients, and soil reaction can be explained, at any rate on broad lines, in terms of its physical, *i.e.*, colloidal, properties.

XXVIII. B. A. Keen. *"The System Soil—Soil Moisture."* Trans. Faraday Society, 1922. Vol. XVII. pp. 228-243.

A general discussion of the relations existing between the soil and its moisture content, with especial reference to the physical significance of the various divisions of soil moisture that have been proposed from time to time.

XXIX. E. M. Crowther. *"Soil Acidity in its Physico-Chemical Aspects."* Trans. Faraday Society, 1922. Vol. XVII. pp. 317-320.

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A general discussion of the methods used for the determination of the acidity and lime requirements of soils, with especial reference to the hydrogen-ion concentration of soil suspensions and the action of neutral salts on acid soils.

XXX. W. B. Haines. *"The Volume-Changes Associated with Variations of Water Content in Soil."* Journal of Agricultural Science, 1923. Vol. XIII. pp. 296-310.

A new and simple method of measuring the shrinkage of moist soil on drying is described, which at the same time gives values for the pore space and specific gravity of the soil. Diagrams are given showing the characteristics of the shrinkage for diverse samples, including pure clay, heavy loam, sandy and peaty soils. The shrinkage is shown to take place in two stages, in both of which there is a linear relationship to the moisture content. The first stage is largely governed by the clay-content of the soil and its limit is fixed by the point at which air begins to replace water in the pores of the soil. The second stage, called the residual shrinkage, is smaller than the first, and seems to depend upon the more highly colloidal material which has been supposed to surround the clay and other particles. Explanation of the shrinkage is developed on these lines with confirmatory experiments.

The effect of alternate wetting and drying of soil in producing a good tilth is illustrated.

XXXI. B. A. Keen and H. Raczkowski. *"The Relation between the Clay Content and Certain Physical Properties of a Soil."* Journal of Agricultural Science, 1921. Vol. XI. pp. 441-449.

A simple experimental method has been described for measuring certain physical constants of soil, using small brass boxes into which soil passing a sieve of 100 meshes to the inch has been packed by hand. The quantities determined are :—

1. The weight of unit volume (1100 ccs.) of air-dry soil, or the apparent specific gravity.
2. Amount of water taken up by unit weight of soil.
3. Pore space.
4. Specific gravity of the soil.
5. The volume expansion of unit volume (100 cc.) of soil when saturated.

The results for one soil only are given, and discussed, to illustrate the method. With the co-operation of the Science Masters' Association it is being applied to a number of soils by various schools.

The particular soil used was obtained in six depths, as follows : 0-6″, 6-12″, 12-18″, 2-3′, 3-4′, and the constants were determined in each depth. It was shown that 1 and 4 varied inversely with the percentage of clay in the soil, while 2, 3, and 5 varied directly with the clay percentages. The effect on the constants of the larger quantities of organic matter present in the top two layers of soil was, weight for weight, approximately equal to that of the clay, except in the volume expansion results where the effect, if any, was within experimental error.

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It is possible that the fraction fine silt II., whose upper limit of diameter is .005 mm., has similar effects to the clay fraction.

XXXII. B. A. Keen. *"Evaporation of Water from Soil II. Influence of Soil Type and Manurial Treatment."* Journal of Agricultural Science, 1921. Vol. XI. pp. 432-440.

Further experiments have been done on the evaporation of water from soil, using the same apparatus and technique as described in an earlier paper. The present series of experiments was designed to investigate the effect of clay content and manurial treatment on the evaporation. Two soils have been used, one containing only 6% clay and the other 15%, and from each soil samples were taken from plots which had received (*a*) no manure, (*b*) artificial manure, (*c*) farmyard manure. The rate at which the soils lost water over concentrated sulphuric acid and at a constant temperature was found to depend firstly on the amount of clay present, and secondly on the amount of organic material in the soil. The differences due to content of organic material were more obvious in the soil containing the larger amount of clay; the farmyard manure plot lost water at the slowest rate, and the unmanured plot occupied an intermediate position. In the sandy soil the differences in evaporation due to manuring were small.

There is evidence that the moisture equivalent of these soils measures the percentage of water at which the evaporation is first directly affected by the soil particles, and that at percentages of water in excess of the moisture equivalent evaporation is taking place substantially from a free water surface.

XXXIII. E. J. Russell and B. A. Keen. *"The Effect of Chalk on the Cultivation of Heavy Land."* Journal of Ministry of Agriculture, 1922. Vol. XXVIII. pp. 419-422.

Measurements taken with a dynamometer showed that dressings of chalk applied 8 years ago were still effective in facilitating cultivation, the saving of drawbar pull being in these trials no less than 180 lb. on a three furrow plough (see p. 12).

THE PLANT IN DISEASE.

INSECT PESTS AND THEIR CONTROL.

XXXIV. A. D. Imms. *"Recent Research on the Head and Mouth-parts of Diptera."* Entomologist's Monthly Magazine. 3rd Series, 1920. Vol. VI. pp. 106-109.

A short discussion of the subject from the morphological standpoint.

XXXV. J. Davidson. *"Biological Studies of* Aphis Rumicis *Linn. IV. Reproduction on varieties of* Vicia Faba*—with a Statistical Appendix by* R. A. Fisher." (See No. XV.) Annals of Applied Biology, 1922. Vol. IX. pp. 135-145.

The reproduction of the bean aphis on 18 varieties of field beans was tested and compared with reproduction on Prolific Longpod broad beans.

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The mean values of infestation for the varieties ranged from 37 to 1,037.

These values allow of the varieties being tentatively grouped into classes representing various degrees of susceptibility ranging from 98% to 3%. The results obtained indicate that resistance or susceptibility may be largely determined by genetic factors in the plant.

XXXVI. J. DAVIDSON. *"Biological Studies of* APHIS RUMICIS *Linn. V. The Penetration of Plant Tissues and the Source of the Food Supply of Aphids."* Annals of Applied Biology, 1923. Vol. X. pp. 35-54.

The food of aphids is the juices of plants which they obtain by penetrating the tissues by means of a delicate piercing organ formed by four chitinous stylets.

The piercing organ passes between the cortical cells—occasionally through individual cells—to the vascular bundles.

The saliva secreted by the aphis acts on the middle lamella of the cell wall. It also causes plasmolysis of the cells; and it is able to convert starch into sugar.

The phlœm tissue is the chief source of the food supply, but other cells of the plant, such as cortex and mesophyll, may be tapped for nourishment.

The sucking out process is usually intracellular, although intercellular suction sometimes goes on.

The varying physiological constitution of different plants or even varieties of the same species of plant is important in relation to the biology and physiology of aphids.

The composition of "honey dew"—the sugary excrement of aphids—is in close relationship with the particular species of plant and aphids concerned.

XXXVII. H. M. MORRIS. *"The Larval and Pupal Stages of the* BIBIONIDÆ. *Part I."* Bull. Entom. Research, 1921. Vol. XII. pp. 221-232.

Deals chiefly with the biology and metamorphosis of *Bibio marci* whose larvæ infest grass-land and have been reported to injure various crops.

XXXVIII. H. M. MORRIS. *"On the Larva and Pupa of a Parasitic Phorid Fly—*HYPOCERA INCRASSATA MEIG.*"* Parasitology, 1922. Vol. XIV. pp. 70-74.

Deals with the biology of a species not hitherto investigated, which parasitizes larvæ of *Bibio marci.*

XXXIX. H. M. MORRIS. *"The Larval and Pupal Stages of the* BIBIONIDÆ. *Part II."* Bull. Entom. Research, 1922. Vol. XIII. pp. 189-195.

An investigation of the biology and metamorphosis of DILOPHUS FIBRILIS and D. ALBIPENNIS, the former species being recorded as injuring the roots of various plants.

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XL. H. M. Morris. *"On a Method of Separating Insects and other Arthropods from Soil."* Bull. Entom. Research, 1922. Vol. XIII. pp. 197-200.

Describes an apparatus consisting of a galvanized framework supporting a graduated series of sieves, which enables arthropods to be separated from soil by means of a current of water.

XLI. H. M. Morris. *"The Insect and other Invertebrate Fauna of Arable Land at Rothamsted."* Annals of Applied Biology, 1922. Vol. IX. pp. 281-305.

A detailed study of the soil fauna of Broadbalk field, involving a comparison of the invertebrata of plots 2 (dunged) and 3 (unmanured), their distribution in depth, and relative numbers. The main conclusions are that the bulk of the fauna is concentrated in the first three inches of the soil, and that there are on an average 15,000,000 invertebrates per acre in plot 2 (receiving farmyard manure annually) and 5,000,000 in plot 3 (unmanured since 1839). The dominant organisms are insects which numbered over 7,700,000 in plot 2 and about 2,500,000 in plot 3. The total amount of the nitrogen contained in these organisms works out at 7349.6 gm. (16.2 lbs.) per acre in plot 2 and 3409.2 gm. (7.5 lbs.) per acre in plot 3. It is unlikely that there is any appreciable loss of this nitrogen from the soil. The observations show that although the introduction of farmyard manure greatly increases the invertebrate population of the soil, the organisms which exhibit increased numbers are saprophagons and not directly injurious to the growing crop.

XLII. J. G. H. Frew. *"On the Morphology of the Head Capsule and Mouth-parts of* Chlorops Tæniopus Meig. *(Diptera)."* Journal Linn. Society, 1923.

The head capsule is described and some modifications suggested of the homology of its facial aspect in Cyclorrhapha as put forward by Peterson in 1916.

The following conclusions are arrived at :—

The dorsal and lateral borders of the oval depression mark the position of the arms of the epicranial sature.

All regions of the head dorsal and lateral to the oval depression are derived from the paired sclerites of the head and the frons and clypeus lie within the depression.

The antennæ arise on the vertex.

The superficial plate of the fulcrum is the clypeus or frontoclypeus.

The tormæ are the chitinised plates joining the sides of the clypeus to the sides of the basipharynx.

XLIII. J. C. F. Fryer, R. Stenton, F. Tattersfield, and W. A. Roach. *"A Quantitative Study of the Insecticidal Properties of* Derris Elliptica *(Tuba Root)."* Annals of Applied Biology, 1923. Vol. X. pp. 18-34.

Extracts of *Derris elliptica* are shown to have a high insecticidal value, particularly for caterpillars. They are not so toxic to aphids.

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The principles of the root toxic to insects are the white crystalline derivative, usually called "tubatoxin," and a resin of a golden yellow colour identical with the "derride" of Sillevoldt.

The dry root itself may be used in a finely powdered condition worked up with water together with soap or other emulsifying reagents.

As the pure poisons found in derris root are solids and only slightly soluble in water, their toxicity appears to depend upon their degree of dispersion.

A biological method of determining insecticidal properties quantitatively is described. It depends on dipping insects for a constant period of time in known strengths of highly dispersed emulsions or suspensoids in dilute aqueous solutions of saponin. Results agreeing with those given by the chemical method described below were obtained, and it enabled a comparison to be made between extracts of derris and nicotine. To certain caterpillars, tubatoxin and derride are shown to be of the same order of toxicity as nicotine.

XLIV. F. Tattersfield and W. A. Roach. *"The Chemical Properties of* Derris Elliptica *(Tuba Root)."* Annals of Applied Biology, 1923. Vol. X. pp. 1-17.

The toxic principles of *Derris elliptica* have been isolated and some of the more simple properties examined. A chemical method for evaluating the root has been outlined and a suitable extraction apparatus described.

The most important constituents of the root are a white crystalline derivative, usually called "tubatoxin," and a resin or a series of resins identical with the "derride" of Sillevoldt and the "tubain" of Wray. Besides these two, yellow crystalline derivatives and a liquid resin were isolated.

"Tubatoxin," the yellow crystalline derivatives, and the resins contain methoxyl groups and these compounds appear to be interrelated. "Tubatoxin" by exposure to light, and by prolonged boiling with organic solvents, is converted into three yellow crystalline products and a resin. This suggests that the "anhydroderride" of Sillevoldt may have been formed during the process of extraction and may not exist as such in the root.

The poisons from the root are readily extracted by means of organic solvents. Ninety-five per cent. alcohol extracts them together with non-toxic derivatives. Benzene, dry ether, carbon tetrachloride are also good solvents for extraction purposes and have a selective dissolving action on the poisons. Petroleum derivatives are not suitable for complete extraction. Prolonged boiling with solvents may cause some loss of toxicity in the extracts owing to chemical change in the "tubatoxin." For economic purposes, benzene and its congeners, or alcohol, are probably the most suitable extraction reagents, provided the temperature of extraction is not allowed to rise too high.

The root may be evaluated by chemical means by extracting the dry root with dry ether, and the genuineness of the extracts confirmed by the determination of the methoxyl content by the Zeisel method. Extracts from different deliveries varied between

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7 and 22 per cent., and the content of CH_3O in the extracts between 13.5 and 14.7 per cent. A qualitative test for "tubatoxin," devised by Dr. Durham, is outlined.

The amounts of the non-toxic constituents vary widely in different consignments. They seem to have some value as emulsifying and wetting agents. As the root, however, arrives in this country in a dry state, in which the constituents have probably coalesced, the use of foreign emulsifying and wetting reagents is necessary, and for maximum efficiency the use of organic solvents for preparing highly dispersed suspensoids appears advisable.

FUNGUS PESTS.

XLV. William B. Brierley. *"On Mutation of Species."* British Medical Journal, 1922, Oct. 21st.

The main genetic bases of "higher organisms" are discussed in relation to the concept of mutation and then in relation to hereditary changes in the protozoa, fungi and bacteria. The concepts of mutation held by microbiologists are considered, and it is shown that they cannot be equated with those applied to "higher organisms." Micro-organisms have not yet been found susceptible to factorial analysis and cytological information regarding the genetic structure and behaviour of their hereditary mechanisms is not available. In the protozoa and fungi, and probably in the bacteria, there is the possibility of the origin of apparently new forms in the normal developmental processes, and it is suggested that "mutations" are due to the selective isolation of such forms.

XLVI. William B. Brierley. *"Some Aspects of Vegetable Pathology in Relation to Human Disease."* British Medical Journal, 1922, Nov. 18th.

The need for extreme caution in making comparison of animal and plant diseases is emphasised, and the lines along which animal and plant pathologists may work in common are suggested. These are mainly comparative morphological, physiological and life history studies of the several pathogens in relation to such problems as systematy, infection, immunity and susceptibility, mutation and other genetic aspects, epidemiology, technique, etc. A plea is made for the definite recognition of a science of medical mycology with adequate teaching and research opportunities.

XLVII. William B. Brierley. *"Comparative Pathology of Plants and Animals."* British Medical Journal, 1922.

The idea of disease accepted in general pathology is that of the invasion of a defensive host by an active parasite, a see-saw balance in which there is an inverse relationship between the health and vigour of the host and the incidence and virulence of the disease. This concept is criticised and evidence given that in diseases of plants it is not necessarily true. The data at present do not allow of such a generalisation and each particular disease complex must be considered separately. The disease complex is

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regarded as the co-ordinated resultant of the activities of the host and parasite each, within the limits of its hereditary constitution, being modifiable by the environment. Lines of comparative research in animal and plant pathology are suggested.

XLVIII. J. Henderson Smith. *"The Killing of Botrytis by Heat, with a Note on the Determination of Temperature Co-efficients."* Annals of Applied Biology, 1923. Vol. X.

When a mass of spores of *Botrytis cinerea* is exposed to the action of moist heat by immersion in water, the individual spores are not all killed simultaneously. A few die quickly, a few after prolonged exposure, and the majority at intermediate periods. The whole process, when the numbers dead at successive intervals of time are plotted against the time, gives a smooth curve, of sigmoid and approximately symmetrical shape. The higher the temperature used, the more quickly does the reaction proceed; but at all the temperatures examined, ranging from 37° C. (where 8-10 hours are necessary for its completion) to 50° C. (where the last spore is killed in about 180 seconds) the curve has the same shape, and the process is exactly the same, except for the change in speed. In this respect the action of heat differs from that of phenol, where the shape of the curve changes progressively as the strength of phenol is raised, from the sigmoid type into a J-type and eventually into a strictly logarithmic curve. The difference is assigned to the occurrence with phenol of a stage of penetration, during which the poison is making its way through the external coat of the spore, a stage which is absent in the case of heat.

The shape of the curve agrees excellently with a recognised type of frequency distribution, and can be adequately and reasonably explained by supposing that the individual spores differ in their susceptibility to the action of heat.

The effect of temperature on the velocity of the reaction is unusually great, and is well expressed by the formula of Arrhenius, if the temperature is reckoned from 0° C. instead of from the absolute temperature. By combination of the formula for the curve and the formula for the temperature-velocity relationship, it is possible to express completely for the spores of Botrytis the whole of the killing process within the limits and under the conditions used in these experiments.

XLIX. J. Henderson Smith. *"On the Apical Growth of Fungal Hyphæ."* Annals of Botany, 1923. Vol. XXXVII. pp. 341-343.

The fungal hypha grows in length exclusively at the tip, and the portion of the hypha behind the extreme tip never elongates after it is once formed. This was determined by direct measurements in a series of fungi selected from widely separated and representative genera, and may be taken as a general rule applicable to all, or at least to most, fungi. In algæ, growth may be apical or may be intercalary; in filamentous bacteria it is intercalary, each segment elongating for itself and at the same rate as the others.

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L. Sibyl T. Jewson and F. Tattersfield. *"The Infestation of Fungus Cultures by Mites."* Annals of Applied Biology, 1922. Vol. IX. pp. 213-240.

Mites are a serious pest of fungus cultures. The species that most frequently occur are *Aleurobius farinæ* and *Tyroglyphus longior,* with an occasional infestation with *Glyciphagus cadaverum.*

They can be controlled by exposing the cultures to the vapour of Pyridine, after which treatment the fungi can be sub-cultured safely. An exact description of the application of the method is given. (Commercial Pyridine is as effective as the pure material.)

If these pests occur in laboratory apparatus, they can be eliminated by the application of strong ammonia. Ammonia and its vapour are very rapidly effective against mites, but they should not be allowed to come into contact with cultures of fungi for too long a period of time in too high a concentration.

Pyridine is shown to have a slight toxic action to fungi, and to inhibit growth completely in certain concentrations which, however, are not at all likely to be objectionable in practice, especially if the treated cultures are sub-cultured.

A brief analysis of the toxic action of Pyridine on both mites and fungi is given.

(*a*) In the case of mites, minute doses have so powerful a paralysing action as to render it probable that Pyridine is specific in its toxic effect to these pests.

(*b*) In the case of fungi, the action of Pyridine upon the germination and growth of *Aspergillus niger* was closely studied. It is shown that up to about .25%, Pyridine has apparently very little toxic action and no feeding effect, but that above this concentration the toxicity increases with great rapidity. It is shown, however, that the toxic action is one of inhibition of germination and that the neutralisation of the base up to 0.6%, the highest concentration tested (even though spores have been exposed to its action for three weeks), permits growth to take place rapidly. Pyridine acts chiefly as a poison through its basic properties but not by the change in the pH of the medium which ensues on its addition.

WART DISEASE OF POTATOES.

LI. William B. Brierley. *"Some Research Aspects of the Wart Disease Problem."* Report of International Potato Conference, London, 1921.

The empiricism of present control methods is emphasised. The disease is a complex state depending upon the physiology and genetical constitutions of the host and the fungus, and this dual entity exists in relation to a changing environment. The several factors in this complex and their relation to the immunity or susceptibility of potato plants to wart disease, are discussed. The problems under investigation at Rothamsted—tuber quality of immunes and non-immunes, nature of immunity, germination and infection studies, soil sterilisation, etc.—are indicated, and other aspects of wart disease research suggested.

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LII. W. A. ROACH. *"Studies in the Varietal Immunity of Potatoes to Wart Disease* (SYNCHYTRIUM ENDOBIOTICUM SCHILB., PERC.)." *Part I.—The Influence of the Foliage on the Tuber as shown by Grafting.* Annals of Applied Biology, 1923. Vol. X. pp. 142-146.

Grafting experiments of a preliminary nature have been carried out to throw light on the functions of the various organs of the potato plant in rendering the tubers immune or susceptible to Wart Disease (*Synchytrium endobioticum* Schilb., Perc.).

Composite plants were built up by grafting in the following ways :—

3 plants of the type	Immune	grafted on	Immune
3 ,, ,,	Susceptible	,,	,,
4 ,, ,,	Immune	,,	Susceptible
2 ,, ,,	Susceptible	,,	,,

The results indicate that the character of the foliage has no influence on the immunity or the susceptibility of tubers to Wart Disease.

It follows that no compound synthetised in the leaves is likely to be responsible for separating potatoes into "immunes" and "susceptibles." The investigation is being continued with the view of finding, if possible, the chemical differences corresponding with the biological differences between immune and susceptible varieties.

TECHNICAL PAPERS.

CROPS AND CROP PRODUCTION.

LIII. E. J. RUSSELL. *"The Barley Crop. A Study in Modern Agricultural Chemistry."* Journal Inst. Brewing, 1922. Vol. XXVIII. pp. 697-717.

Barley, like wheat, flourishes best in relatively dry conditions, and the map showing its distribution in England and Wales is much like an inversion of the rainfall map. In Norfolk it occupies no less than 15% of the land in cultivation and in other counties of low rainfall it occupies between 9% and 14%; in the wetter counties, however, it occupies much less. The yield is chiefly determined by the quantity of nitrogen supplied. When barley is grown year after year on the same ground at Rothamsted the yield steadily falls off for some reason which cannot yet be found. This falling off is less with farmyard manure than with artificial fertilisers. In ordinary farm practice there is no indication of falling yields, but rather the contrary; given adequate manuring, however, the yield is still limited by the season and the strength of the straw.

It is often stated that the quality or malting value of the barley is inversely related to the nitrogen content of the grain, and where large differences are concerned this is generally true. But on any given farm it does not appear that the nitrogen content is much affected by the manuring so long as the conditions are not profoundly altered; the valuation also is not influenced in any regular way.

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High malting value seems to be associated with favourable conditions during the second part of the plant life when vigorous growth is followed by good ripening. These conditions almost necessitate a low nitrogen content since nitrogen assimilation occurs mainly in the early part of the plant life ; if there is vigorous growth afterwards it is mainly an accumulation of non-nitrogenous material. In these conditions, therefore, low nitrogen content would be related to malting value. But a low nitrogen percentage might equally result from a low nitrogen intake in the early life of the plant, and in this case there would be no necessary relationship with malting value.

LIV. E. J. Russell. *"Report on the Experiments on the Influence of Soil, Season and Manuring on the Quality and Growth of Barley, 1922."* Journal Inst. Brewing, 1923. Vol. XXIX. pp. 624-654.

Experiments have been made on a uniform plan on a number of farms known to grow barley well. The yields are given on p. 104, as also are the percentages of nitrogen and the values assigned by the maltsters. As this is the first year of the experiments, no conclusions are drawn ; the following results, however, were obtained :—

Nitrogenous manure (sulphate of ammonia) produced its usual effect of increasing the yield by about 5 bush. for 1 cwt. sulphate of ammonia, excepting only in two or three readily explained cases. The valuation was usually unaltered, but in one case it was increased and in two cases reduced.

Phosphates were ineffective at several centres on heavy soils where they would normally be expected to act. On the very light sand they apparently depressed the crop. We believe this to be a true effect attributable to the well-known action of phosphates in accelerating maturation. If this is confirmed by later observations it will necessitate a modification in the manurial treatment of barley on light land.

Contrary to our expectation in this bad season, potassic fertiliser was without effect on the valuation, although it had in several cases a marked effect in increasing yield.

The indication of this season's experiments are that a farmer can vary his manurial treatment within the limits of usual practice without influencing the maltsters' valuation.

The nitrogen content was usually related to maltsters' valuations when the barleys from different farms were compared, but the relationship was much less marked (only about half) when the barleys from differently manured plots on the same farm were compared. This result agrees with that already recorded above.

FERTILISERS.

ORGANIC MANURES.

LV. E. H. Richards and G. C. Sawyer. *"Further Experiments with Activated Sludge."* Journal of the Society of Chemical Industry, 1922. Vol. XLI. pp. 62T-71T.

If activated sludge is aerated for a short period in an ammoniacal solution there is no loss of nitrogen, any nitrogen not

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found as ammonia or nitrate in the effluent being recovered in the sludge. There is considerable evidence that the extra nitrogen in activated sludge, over and above that found in the old type sludges, is derived from the ammonia of sewage. There is no evidence of fixation of atmospheric nitrogen. The numbers of protozoa in well-activated sludge approximate to 1,000,000 per gram of wet sludge. The cell content of these organisms alone may account for a large proportion of the extra nitrogen. There is complete correlation between the numbers of active protozoa and bacteria in activated sludge under varied conditions of working.

Observations made in working the experimental tank at Harpenden Sewage Works confirm the laboratory experiments designed to find the source of the extra nitrogen content of activated sludge compared with ordinary sewage sludges. They afford no evidence of fixation of atmospheric nitrogen, but suggest that in addition to colloidal nitrogen, ammonia is removed from the sewage by physical or biological means, or both. The proportion of total nitrogen in the Harpenden sewage recovered in normal working by the activated sludge process is greater than in the older methods of sewage purification, *viz.*, 15% compared with 10% by precipitation and 4% by septic tanks. With sewage of half the average strength and supplying twice the normal volume of air per gallon of sewage, the recovery of nitrogen was as high as 27% of the total nitrogen in the sewage. Field trials show that activated sludge has a high manurial value in marked contrast with the old type sewage sludges tested on the Rothamsted farm in past years.

LVI. H. J. Page. *"Green Manuring."* Journal of Ministry of Agriculture, 1922. Vol. XXIX. pp. 104-112; 240-248.

Green manuring is discussed as a substitute for dung, the supply of which is insufficient. Variation in type of soil, climate, system of cropping and the like, necessitates different systems of green manuring; similarly the maintenance of productive soils in good heart by green manuring is a problem distinct from that of building up the fertility of run-down or naturally infertile land. Thus such systems of green manuring as find application in this country vary considerably from district to district. Although the beneficial effect of green manures, and of dung, depends on a variety of factors (which are discussed in detail), the prime function of either is to supply humic material to the soil. Artificials can fulfil most of the other functions of green manures or dung, but not this one.

LVII. H. J. Page. *"Saving Expense by Green Manuring."* Modern Farming, 1923. Vol. VI. No. 9.

In seeking to develop the use of green manuring as a substitute for dung, one of the greatest difficulties encountered is that of fitting the green crop into the rotation, without disturbing the latter. In practice this resolves itself into growing the green crop (i.) during the autumn and winter before roots, (ii.) in early autumn before winter corn. The first method finds application in potato districts (of which instances are quoted), but its feasibility as a preparation for mangolds or swedes is uncertain, and merits