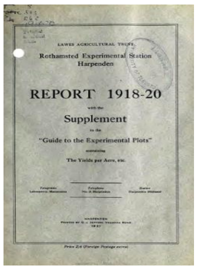
Report 1918-20 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



Summary of Papers Published - I. Scientific Papers

Rothamsted Research

Rothamsted Research (1921) *Summary of Papers Published - I. Scientific Papers ;* Report 1918-20 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 28 - 52 **- DOI: https://doi.org/10.23637/ERADOC-1-109**

PUBLICATIONS DURING THE YEARS 1918-20.
SCIENTIFIC PAPERS.

CROPS AND PLANT GROWTH.

I. WINIFRED E. BRENCHLEY. "*Some Factors in Plant Competition.*" Annals of Applied Biology, 1920. Vol. VI. pp. 142-170.

The competition exhibited when plants of the same or different species grow in juxtaposition is complex and includes :—

1.—Competition for food from the soil. 2.—Competition for water. 3.—Competition for light. 4.—The possible harmful effect due to toxic excretions from the roots, if such occur.

The general effect of competition (including 1, 2, 3 above) has been studied in pot cultures, when a varying number of plants are grown in the same bulk of soil. The effect of competition for light was investigated by means of water cultures, in which a number of plants each equally furnished with food and water, were crowded together as closely as possible, while a similar set of plants was given sufficient space to avoid the shading of one plant by another.

With limited food supply the dominant factor in competition is the amount of food and particularly of available nitrogen. Other things being equal, the dry matter produced is determined by the nitrogen supply, irrespective of the number of plants drawing thereon.

With limited food supply the efficiency index of dry weight production decreases with the number of plants, as the working capacity of the plant is limited by the quantity of material available for building up the tissues.

(N.B.—" Efficiency Index " is the term employed by V. H. Blackman to express the rate per cent. at which the dry matter of a plant increases during growth.)

3.—The decrease in light caused by overcrowding is a most potent factor in competition, even when an abundance of food and water is presented to each individual plant. With barley the effect of light competition is to reduce the number of ears ; to cause great irregularity in the number of tillers produced ; to reduce the amount of dry matter formed ; to encourage shoot growth at the expense of root growth, thus raising the ratio of shoot to root ; to increase the variation in the efficiency indices of dry weight production of a number of crowded plants, lowering them on the average ; to decrease the power of the plants to make use of the food supplied to the roots, as evidenced by the total quantity of nitrogen taken up by similar numbers of plants when spaced out and crowded.

4.—With adequate illumination (in barley) there is a tendency towards the production of a standard type of plant in which the relation between the number of tillers and ears, dry weights, efficiency indices, and ratios of root to shoot approximates within variable degrees to a constant standard. With overcrowding, this approximation entirely disappears.

II. WINIFRED E. BRENCHLEY. "*On the Relations between Growth and the Environmental Conditions of Temperature and Bright Sunshine.*" Annals of Applied Biology, 1920. Vol. VI. pp. 211-244.

The amount of growth made by any crop in the field and the rate at which maturity is reached are influenced by many factors, such as temperature, rainfall, season, sunlight, soil conditions and available plant food. An attempt was made to isolate some of these factors by growing a number of series of peas in water cultures throughout a period of sixteen months, results being thus obtained for all seasons of the year. Measurements of maximum and minimum temperatures and number of hours of bright sunshine were recorded throughout, and provided a basis for statistical correlations. Parallel series were usually grown, in one of which the nutrient solutions were changed weekly so that an abundant food supply was assured, whereas in the other the solution was not renewed, and the food supply was severely restricted.

It was found that growth may be divided conveniently into two well-marked periods.

(*a*) 1st period, from the seedling stage till the time that the plant regains its initial weight after the loss by respiration, *i.e.*, the time during which a casual observer would say the plant "makes no growth."

(*b*) 2nd period, succeeding the former, during which the plant is obviously making growth, and which continues till the latter ceases and dessication sets in.

The length of the first period varies inversely with the mean maximum temperature, as the rate at which assimilation is able to make good the loss by respiration increases directly with rise of temperature, up to a certain limit.

The possible amount of growth, as measured by the dry matter produced, depends entirely upon the bright sunshine and temperature when the food supply is adequate, but when the latter is limited the total growth is much less owing to the lack of material for building up the tissues. Beyond a certain limit, however, the beneficial factors of heat and bright sunshine become harmful and result in the premature death of the plant.

During the first period the rate of growth, as shown by the efficiency index, was associated with relatively warm days and nights, bright sunshine having little significant effect; the light, however, was good throughout for the season of the year. During the second period the rate was associated strongly with sunshine and warm days, but not significantly with the night temperatures, which did not fall below 32° F.

During the greater part of the year the maximum rate of growth is reached early in life, but in winter, when temperatures are low and there is little bright sunshine, the maximum rate is not attained till much later.

Plants with a restricted food supply make less total growth than those with abundant food. The falling off in the amount of dry matter produced does not seem to be gradual but is marked by definite periods, of which the incidence varies at different seasons.

During the period of actual growth, the shoot increases in weight far more rapidly than the root. Increase in shoot growth is closely associated with rise in temperature and root growth is adversely affected by low mean maximum temperatures. Rise in maximum temperature has much less beneficial action upon the roots than upon the shoots.

In early stages of growth, the amount of nitrate absorbed by the plant is relatively large in comparison with the dry matter produced, but later on more dry matter is formed in proportion to the

https://doi.org/10.23637/ERADOC-1-109

samè amount of nitrate, owing to the accumulation of the products of assimilation.

III. WINIFRED E. BRENCHLEY and VIOLET G. JACKSON. "*Root Development in Barley and Wheat under different conditions of Growth.*" Annals of Botany, 1921.

Investigations have been begun on the effect of various manures as superphosphate, sulphate of potash and nitrate of soda on the root systems of barley and wheat. Most of the experiments were made in pot cultures and the roots washed out at regular intervals to obtain the various stages of development. Two forms of roots are produced:—

1.—Much branched roots, most of which proceed from the grain. These are rather thin, long, and bear very numerous fine laterals, with root hairs only near the tip.

2.—Thick unbranched roots arising from the nodes as well as the grain, white in colour, and densely clothed with root hairs throughout their length. At a later stage these roots branch and approximate more closely to the others in appearance.

With *barley*, superphosphate encourages the development of unbranched roots, sodium nitrate having no effect. When the plants are about three months old no more unbranched roots seem to be formed. The maximum root development was reached at about the time that the ears were ready to emerge from their sheaths, *i.e.*, when pollination and fertilisation of the ovule were about to take place. With superphosphate alone and with nitrate alone, however, this maximum was reached somewhat earlier, so that apparently root growth culminated with the final stage of preparation by the plant for grain formation. In other words, during the period of purely vegetative growth the plant needs large supplies of nitrogen and ash constituents to aid in building up a strong shoot in readiness for grain formation, and the root steadily increases in order to be able adequately to cope with this demand. During the reproductive phase, on the other hand, vegetative development is reduced to a minimum, and the whole of the plant's energy is diverted towards the grain. Although nitrogen and ash constituents are just as essential as before, the area of supply is increased, as migration of these substances from the straw into the grain goes on from the outset. This reduces the strain on the root, and as such a large absorbing area is no longer required it appears that the excess provision may be got rid of by a steady process of decay, as the weight of the root steadily decreases when once the maximum is reached. The ratios of root to shoot at different periods are also discussed, a great increase of the shoot/root ratio occurring where the unbranched roots cease to be formed.

With *wheat* the unbranched roots increase in numbers less rapidly than in barley, but persist as such for a longer period.

There is in wheat nothing to correspond with the sudden disappearance of white roots which occurs in barley about 11 weeks after sowing, for in wheat the decline in white roots coincides with the decrease in weight of the complete root system, whereas in barley the formation stops suddenly when the ratio between shoot and root growth begins to change.

The paper concludes with a discussion of :—

1.—The influence of environmental conditions other than manuring upon root growth.

2.—Influence of different types of manuring upon root growth.

IV. WINIFRED E. BRENCHLEY. "*The Development of the Flower and Grain of Barley.*" Journal of the Institute of Brewing, 1920. Vol. XXVI. pp. 615-632.

An account is given of the development of the ear and flower of barley from the time the young ear is about ¼-inch long until the grain is fully developed. The method of flowering in barley is to a large extent characteristic of the type, as in some cases the glumes open and in others remain closed at the time of pollination. With closed-glume flowering cross-fertilisation is of course impossible, and even with open flowering it is the exception rather than the rule.

The developmental history of the grain indicates that the awns are of considerable physiological importance, and in every barley ear the largest and heaviest grains are in the middle of the ear, and the longest awns occur on these grains, indicating some correlation between weight of grain and length of awn. The awns are essentially transpiring organs. Transpiration is most active during the development of the spike and grains, rising to a maximum just about the time the grains reach the milk stage.

V. MARY D. GLYNNE, B.Sc. and VIOLET G. JACKSON, B.Sc. "*The Distribution of Dry Matter and Nitrogen in the Potato Tuber (variety, King Edward).*" Journal of Agricultural Science, 1919. Vol. IX. pp. 237-258.

King Edward Potatoes were grown in 1917 on Little Knot Wood Field, Rothamsted, lifted about the end of September, 1917, and examined in the laboratory early in 1918.

The percentage of dry matter in the potato tuber was lowest in the skin; it increased to the inner cortical layer, the zone containing the greater part of the vascular system, and decreased towards the centre of the tuber. Typical results are :—

DRY MATTER IN DIFFERENT ZONES OF THE TUBER.

Zone.	SMALL 54-84.5 gms. % of whole.	SMALL 54-84.5 gms. % dry matter.	MEDIUM 139.5-169.2 gms. % of whole.	MEDIUM 139.5-169.2 gms. % dry matter.	LARGE 184.9–259.9 gms. % of whole.	LARGE 184.9–259.9 gms. % dry matter.	AVERAGE of 18 tubers. % dry matter.
Skin . . .	2.78	14.29	1.85	15.08	2.83	13.44	14.01
Cortical, outer	27.54	24.86	20.29	23.43	18.11	23.36	23.71
,, inner	24.68	29.25	20.11	28.72	18.92	27.57	28.30
Medullary, outer	31.32	25.76	36.43	25.49	39.95	25.05	25.28
,, inner	13.67	20.19	21.32	18.46	20.19	17.48	18.15
Cortical, outer & inner	52.22	26.93	40.40	26.08	39.03	25.52	26.00

In each zone the proportion of dry matter is higher towards the umbilical than the terminal end of the tuber.

The percentage of nitrogen in the fresh material tends to decrease from the skin to the inner cortical layer and to increase in the medullary zone. Thus it increases from zone to zone in the opposite direction to the dry matter.

Nitrogen tends to increase with dry matter from the terminal to the umbilical end. The results are :—

Average of 3 Small Tubers.

	Section 1	Section 2	Section 3	Section 4
Skin	0.40	0.42	1.13	0.42
Cortical, outer . . .	0.35	0.36	0.37	0.40
,, inner . . .	0.29	0.29	0.32	0.32
Medullary, outer . .	0.30	0.32	0.34	0.29
,, inner . .	0.33	0.36	0.39	0.40

Average of 3 Medium Tubers.

	Section 1	Section 2	Section 3	Section 4
Skin	0.26	0.40	0.45	0.45
Cortical, outer . . .	0.33	0.33	0.34	0.37
,, inner . . .	0.29	0.30	0.33	0.35
Medullary, outer . .	0.30	0.34	0.37	0.38
,, inner . .	0.34	0.32	0.30	0.36

Average of 3 Large Tubers.

	Section 1	Section 2	Section 3	Section 4
Skin	0.45	0.36	0.51	0.54
Cortical, outer . . .	0.33	0.34	0.35	0.41
,, inner . . .	0.32	0.37	0.35	0.38
Medullary, outer . .	0.30	0.35	0.44	0.40
,, inner . .	0.32	0.32	0.36	0.38

Microscopical examination shows the starch grains densest in the region of the vascular system, and decreasing towards the centre and surface of the tuber.

A high degree of correlation is found between the specific gravity and percentage of dry matter of whole tubers.

For purposes of sampling the method of taking two radially opposed sectors, or diagonally opposed eighths, was far more accurate than the coring method.

https://doi.org/10.23637/ERADOC-1-109

VI. O. N. PURVIS. "*The Effect of Potassium Salts on the Anatomy of Dactylis Glomerata.*" Journal of Agricultural Science, 1919. Vol. IX. pp. 338-365.

Stems of *Dactylis glomerata* were collected from grass plots which had received different manurial treatment as regards potash.

The yield of hay from these plots during the period of the investigation was in close agreement with the average, showing that the season was not abnormal.

The thickness of the wall, the diameter of the lumina and the ratio of the lumen to the wall were measured both in sclerenchyma and metaxylem elements. In the early stages the sclerenchyma walls were thinner where potash had been supplied, but this effect was lost as the season progressed.

The lumina were larger in plants which had received potash when nitrogenous fertilisers had not been added, but in the presence of ammonium salts, this effect was reversed.

In the xylem the thickness of the walls was unaltered, whether potassic fertilisers were added or not. When no nitrogenous manures were added the diameter of the lumen was decreased in the presence of potash, but when ammonium salts had been applied, the diameter was increased by the application of potassic fertilisers.

The addition of potassium salts produced an increased ratio of lumen to wall, but this effect gradually passed off. Presumably, therefore, potassic fertilisers reduced the strength of mechanical cells in the early stages of growth. This conclusion, however, would not hold if potassium salts affected the composition of the wall.

From these results it is concluded that the rigidity of plants supplied with potassium salts is not the result of anatomical strengthening, but must be attributed to other causes, such as the influence of the salts on the physiological condition of the plant, or on its chemical composition.

VII. R. A. FISHER. "*Studies in Crop Variation. An Examination of the Yields of Dressed Wheat from Broadbalk.*" Journal of Agricultural Science, 1921. Vol. XI.

A study of the variations in yield on Broadbalk where wheat has been grown continuously since 1843.

Three types of variation are found due respectively to (1) annual causes, primarily weather; (2) steady deterioration of the soil; (3) other slow changes, among which changes in weed flora are considered. The effect of weather is reserved for further consideration. The effects of soil deterioration and other slow changes are studied at length.

On the unmanured plot, the decrement in yield is of the order of 0.8%, or less than 1 bushel in 10 years. If this rate were maintained, the plot would still last out another 125 years. Where farmyard manure is applied there is practically no falling off in yield; this crop also shows the least variation due to weather. With complete artificials, however, there is a deterioration, but less with heavy than with light dressings of ammonium salts, which is not quite in accordance with the Law of Diminishing Returns. With incomplete artificials, however, the falling off is more marked, exceeding that of the unmanured crop. The figures are :—

Plot.	Manure.	Mean yield Bushels per acre.	Mean annual decrement Bushels per acre.	Mean annual decrement %
3 & 4	None . . .	12.27 ± .39	.097	.79 ± .16
2b.	Farmyard manure .	34.55 ± .74	.031	.09 ± .11
8	Complete artificials (treble ammonia)	35.69 ± .93	.092	.26 ± .14
7	Do. (double ammonia)	31.37 ± .90	.144	.46 ± .15
6	Do. (single ammonia)	27.58 ± .71	.141	.62 ± .19

INCOMPLETE ARTIFICIALS.

Plot.	Manure.	Mean yield in Bushels per acre.	Mean annual decrement. Bushels per acre.	Mean annual decrement. %
12	Sulphate of soda .	28.32 ± .98	.181	.64 ± .18
13	Sulphate of potash .	30.21 ± .91	.123	.41 ± .16
14	Sulphate of magnesia	27.76 ± .90	.231	.83 ± .17
7	All three sulphates .	31.37 ± .90	.144	.46 ± .15
11	None of the sulphates	22.05 ± .91	.219	.99 ± .21

The existence of the third type of variation precluded the possibility of obtaining true curves of exhaustion.

The paper contains a detailed analysis of the mathematical methods employed for the deduction of statistically homogenous material for the further study of meteorological effects.

RAIN.

VIII. E. J. RUSSELL and E. H. RICHARDS. "*The Amount and Composition of Rain falling at Rothamsted.*" (Based on analyses made by the late Norman H. J. Miller.) Journal of Agricultural Science, 1919. Vol. VIII. pp. 309-337.

The ammoniacal nitrogen in the Rothamsted rain-water amounts on an average to 0.405 parts per million, corresponding to 2.64lb. per acre per annum. The yearly fluctuations in lb. per acre follow the rainfall fairly closely. The monthly fluctuations also move in the same direction as the rain, but the general level is highest during May, June, July and August, and lowest during January, February, March and April.

The nitric nitrogen is on an average one-half the ammoniacal, *viz.*, 1.33lb. per acre per annum. The amounts fluctuated year by year and month by month in the same way as the ammoniacal nitrogen and the rainfall until 1910, since when there has been no simple relationship.

Reasons are adduced for supposing that the ammonia arises from several sources. The sea, the soil and city pollution may all contribute. Neither the sea nor city pollution seems able to account for all the phenomena: the soil is indicated as an important source by the fact that the ammonia content is high during periods of high biochemical activity in the soil, and low during periods of low biochemical activity.

The close relationship between the amounts of ammoniacal and nitric nitrogen suggests either a common origin or the production of nitric compounds from ammonia.

The average amount of chlorine is 2.43 parts per million, bringing down 16lbs. per acre per annum. The fluctuations closely follow the rainfall both month by month and year by year, but the general level is much higher during the months September to April than during the summer months. It seems probable that the chlorine comes from the sea, but some may come from fuel.

Since 1888, when the experiments began, to 1916, when they terminated, there has been a rise in the amounts of nitric nitrogen and of chlorine in the rain. In the case of chlorine a parallel series of determinations made at Cirencester over the same period shows a similar rise. There is no rise of ammonia, but on the contrary a tendency to drop: the sum of ammoniacal and nitric nitrogen shows little change over the period. This seems to suggest that a former source of ammonia is now turning out nitric acid: it is possible that modern gas burners and grates tend to the formation of nitric oxides rather than of ammonia.

Rain contains on an average 10 parts of dissolved oxygen per million, the amount being higher in winter than in summer: 66.4lbs. per acre per annum were brought down during the two years over which the determinations extended.

The marked difference in composition between summer and winter rainfall suggests that these may differ in their origin. The winter rain resembles Atlantic rain in its high chlorine and low ammonia and nitrate content: the summer rain is characterised by low chlorine but high ammonia and nitrate content, suggesting that it arises by evaporation of water from the soil and condensation at higher altitudes than in the case of winter rain.

CHANGES OCCURRING IN THE SOIL.

IX. E. J. Russell and E. H. Richards. *"The Washing Out of Nitrates by Drainage Water from Uncropped and Unmanured Land."* (Based on analyses made by the late N. H. J. Miller.) Journal of Agricultural Science, 1920. Vol. X. pp. 22-43.

An investigation of the results obtained by the drain gauges set up by Lawes and Gilbert in 1870.

At the beginning of the experiment the soil contained 0.146% of nitrogen, or about 3,500lb. per acre in the top 9 inches; it yielded up to about 40lb. of nitrogen per acre per annum to the drainage water. At the end of nearly 50 years it still contains 0.099% of nitrogen, or 2,380lb. in the top 9 inches, and it still gives up to the drainage water 21lb. of nitric nitrogen per acre per annum, enough to produce a 15 bushel crop of wheat, although neither manure nor crop residues have been added during the whole of the period. If the curve showing the rate of fall continued its present course and without further slowing down, no less than 150 years would be needed for exhaustion of the nitrogen.

So far as can be ascertained, the nitrogen lost from the soil appears wholly as nitrate in the drainage water. From the top 9 inches of the 20in. and 60in. gauges, the nitrogen lost has been respectively 1,124 and 1,172lb. per acre. The nitric nitrogen in the drainage water amounts to 1,247 and 1,200lb. per acre in the two gauges. These figures are arrived at by adding together the whole of the nitrate found and such estimated amounts as are possible for the first seven years before regular determinations were made, deducting nitrogen introduced by rain. The subsoil is left out of account, but evidence is adduced to show that it contributed little, if anything, to the nitrate in the drainage water.

There is no indication of fixation of nitrogen or loss of gaseous nitrogen. The soil is, however, now very poor in organic matter.

The amount of nitrate washed out is closely related to the rainfall and to a less extent to the sunshine of the preceding summer.

It is difficult to account for the slow rate of removal of nitrogen from the soil unless one introduces into the ordinary cycle some new element acting as a kind of immobiliser, absorbing nitrates or ammonia as they are produced and giving them up again later on. The case would be met if one supposed that some of the soil organisms, such as algæ, bacteria, fungi, etc., assimilated nitrates or ammonia and on their death were themselves decomposed, giving rise ultimately to nitrates again. On this view the nitrogen compounds of the soil would be supposed to break down with formation of ammonia and then nitrate, but only a portion, and not the whole, of this nitrate is liable to loss or assimilation by plants: the remainder would be taken up by organisms, temporarily immobilised, but re-formed on the death and dissolution of the organisms, when again part would be thrown out of the cycle and reabsorbed.

X. D. J. Matthews. "*The Determination of Ammonia in Soil.*" Journal of Agricultural Science, 1920. Vol. X. pp. 72-85.

An aeration method for determining the quantity of ammonia in the soil with more accuracy and in shorter time that hitherto, it being possible to recover 99.5% of added ammonia as against a recovery of 50-60% by the older methods. For details the paper must be consulted.*

The results of application to natural soils is to confirm the older conclusion that ammonia is present in minimal quantities only, but it now becomes possible to follow accurately the changes that occur when stubble or green manure are ploughed in, or when ammoniacal fertilisers are added to the soil.

*Or Soil Conditions and Plant Growth. 4th. ed. 1921, p. 349.

XI. G. A. Cowie. "*The Mechanism of the Decomposition of Cyanamide in the Soil.*" Journal of Agricultural Science, 1920. Vol. X. pp. 163-176.

This paper is of interest as showing the occurrence in the soil of changes which apparently are not brought about by micro-organisms, but by active chemical agents not yet clearly recognised.

It is known (see p. 55) that cyanamide undergoes decomposition in the soil before it can be utilised by the crop as a fertiliser. It is now shown that the decomposition proceeds in three stages: (1) cyanamide gives rise to urea; (2) urea gives rise to ammonia; (3) the ammonia is oxidised to nitrate. The first stage, the formation of urea, seems to be brought about by a chemical agent and not by micro-organisms, but the agent has not yet been discovered. The change proceeds more rapidly in clay than in sandy soils, and it does not take place at all in pure sand, in peat, or in fen soils. There is some indication that the decomposition agent may be a zeolite or active silicate. A sample of Thanet sand taken from a boring through the London Clay near Chelmsford was found, even after ignition, to be active in decomposing cyanamide into urea. This particular sand has been shown to contain a constituent resembling a zeolite in being reactive and possessing the property of softening hard water by the substitution of sodium salts and possibly potassium for those of calcium and magnesium. In following up this clue it was found that the addition of a definite zeolite prehnite to ordinary inert sand produces a mixture capable of converting cyanamide into urea.

The decomposition of urea and the oxidation of ammonia are then brought about by micro-organisms in the usual way.

XII. V. A. Beckley. "*The Formation of Humus.*" Journal of Agricultural Science, 1921. Vol. XI. pp. 69-77.

Setting out from an observation by Fenton it is shown that sugars, on treatment with acids, give rise to hydroxymethylfurfuraldehyde, which readily condenses to form a substance closely resembling humus. The author found indications of hydroxymethylfurfuraldehyde in a dunged soil and in rotting straw in which humus was being produced. He suggests, therefore, that the formation of humus in the soil proceeds in two stages:—

1.—Carbohydrates react with acids to produce hydroxymethylfurfural.

2.—Hydroxymethylfurfural condenses to form humus.

In addition, in the laboratory, there is produced some furfural and lævulinic acid.

No evidence of the formation of hydroxymethylfurfural during the decomposition of cellulose by *Spirochæta cytophaga* could be obtained.

XIII. V. A. Beckley. "*The Preparation and Fractionation of Humic Acid.*" Journal of Agricultural Science, 1921. Vol. XI. pp. 66-68.

The author finds that humus may be fractionated according to the following scheme:—

Soil treated with Ammonia

Black solution
Treated with Acid

Insoluble humin

Solution
Mulder's apocrenic
acid

Precipitate
Humus
Treated with Alcohol

Solution
Hoppe-Seyler's
hymatomelanic acid

Residue
Humic acid

Treated with Pyridine

Melanin

Compounds obtained
by Schreiner and
Shorey

Soluble
humic acid

Insoluble
humic acid

The above procedure has been repeated with rotted straw and with sugar humus, and in both cases similar fractions were obtained. The residue after pyridine extraction of sugar humus was, however, only slowly soluble in ammonia, probably having been converted into humin.

SOIL ORGANISMS.

XIV. L. M. Crump. "*Numbers of Protozoa in certain Rothamsted Soils.*" Journal of Agricultural Science, 1920. Vol. X. pp. 182-198.

The method used was an improvement on that previously adopted in this laboratory, but it did not discriminate between active and encysted forms. Determinations were made at intervals of about seven days of the numbers of total protozoa and bacteria in the soil of Broadbalk Plot 2, which receives 14 tons of farmyard manure in each year, and of Harpenden Field, which is typical of poor arable land. The results are plotted on curves from a study of which the following conclusions are drawn :—

1.—Flagellates, amœbæ and thecamœbæ are usually present in these soils in the trophic condition and in comparatively large numbers, so that there is an extensive population actively in search of food.

2.—The protozoan fauna is practically confined to the top six inches of the soil.

3.—There is a definite inverse relation between the numbers of bacteria and amœbæ.

4.—The amœbæ are uninfluenced by variations in the water content and temperature of the soil and by the rainfall.

5.—The richer the soil is in organic matter the richer it is in protozoa, especially in amœbæ and thecamœbæ.

These conclusions are at variance with those arrived at by the American investigators, but it is believed that the methods employed are better than those used in America.

XV. D. W. Cutler. "*A Method for Estimating the Number of Active Protozoa in the Soil.*" Journal of Agricultural Science, 1920. Vol. X. pp. 135-143.

This method constitutes a great advance on those previously in use, since it discriminates between active and encysted forms; it has, therefore, been adopted in all the succeeding work. The soil is passed through a 3mm. sieve and two samples of 10 grams each are taken. In one the total number of protozoa (active forms plus cysts) is determined as follows: 10 grams of the sieved soil are added to 100 cc. of sterile tap water or physiological salt solution. This gives a 1/10 dilution. From it further dilutions are made as shown below.

No.	1	. .	10	gm. soil	in	100	cc. H_2O	=1/10	dilution.
	2	. .	10	cc. No.	1 ,,	90	,,	=1/100	,,
	3	. .	5	,, ,,	2 ,,	45	,,	=1/1,000	,,
	4	. .	20	,, ,,	3 ,,	30	,,	=1/2,500	,,
	5	. .	20	,, ,,	4 ,,	20	,,	=1/5,000	,,
	6	. .	30	,, ,,	5 ,,	15	,,	=1/7,500	,,
	7	. .	30	,, ,,	6 ,,	10	,,	=1/10,000	,,
	8	. .	20	,, ,,	7 ,,	30	,,	=1/25,000	,,
	9	. .	20	,, ,,	8 ,,	20	,,	=1/50,000	,,
	10	. .	30	,, ,,	9 ,,	15	,,	=1/75,000	,,
	11	. .	30	,, ,,	10 ,,	10	,,	=1/100,000	,,

Nutrient agar is poured into sterile Petri dishes. When the medium has solidified, the dishes are inoculated in pairs with 1 cc. of each dilution. Incubation at 20° is continued for 28 days, and the plates examined at intervals of 7 days, 14 days, 21 days and 28 days. This long period of incubation is necessary in order to ensure accurate results.

In the other 10 gram sample the cysts only are determined, advantage being taken of the fact that they survive treatment with 2% hydrochloric acid while active forms do not. The soil is therefore treated with sufficient 2% HCl to neutralise the carbonate present and still leave an excess of unchanged 2% acid. The acid is allowed to act overnight. After treatment, the number of protozoa in the sample is ascertained by the dilution method; this gives the number of cysts since the acid has killed all the active forms, leaving most of the cysts unharmed. The number of cysts subtracted from the total number of organisms given by the first count gives the number of active protozoa per gram of the soil sample.

XVI. D. W. Cutler and L. M. Crump. "*Daily Periodicity in the Numbers of Active Soil Flagellates, with a brief note on the Relation of Trophic Amœbæ and Bacterial Numbers.*" Annals of Applied Biology, 1920. Vol. VII. pp. 11-24.

Using the preceding method, it was found that the numbers of protozoa varied so rapidly that weekly counts did not fairly represent the changes taking place. A series of daily counts was therefore projected and continued for 28 days—from February 9th to March 8th. During the last 14 days the bacteria also were counted. The following conclusions were drawn :—

1.—There is a daily variation in the number of trophic forms of the three species of flagellates, *Oicomonas sp.* (Martin), *Cercomonas Longicauda* and *Bodo sp.*, in the soil of arable fields.

2.—The numbers of bacteria and trophic amœbæ in the soil are correlated, varying inversely over a period of 14 days.

3.—Temperature and rainfall appear to have no influence on the number of active protozoa in the soil.

(Note.—In view of the importance of these results counts were begun on July 4th, 1920, and have gone on daily ever since: it is proposed to continue these for 365 consecutive days.)

XVII. D. W. Cutler. "*Observations on Soil Protozoa.*" Journal of Agricultural Science, 1919. Vol. IX. pp. 430-444.

It is shown that soil possesses a remarkable power of retaining protozoa. When a suspension of protozoa is shaken with soil all the organisms are withdrawn until the saturation point is reached, after which, for the first time, the supernatant liquid contains protozoa. Some of the results are :—

	Active flagellates and amœbæ millions per c.c. of suspension			
Before shaking with soil	.56	1.64	1.98	2.80
After ,, ,, ,, ...	Nil.	Nil.	0.29	1.04
Number taken up per gram of soil .	All	All	1.69	1.76

Until the soil has absorbed 1.7 millions per gram there is complete retention of the organisms.

One gram of coarse sand is capable of withdrawing approximately 145,000 amœbæ and flagellates from a suspension of any strength. Fine sand withdraws approximately 980,000 : soil and partially sterilised soil 1,650,000, ignited soil 1,500,000, and clay 2,450,000 per gram of material in each case.

These figures are constant for given material and organisms, and are independent of the concentration of the suspensions, the time of action, or whether the suspension contains cysts or active forms of the amœbæ and flagellates investigated. Also the action is the same when the experiment is performed with a suspension of living or dead organisms.

Experiments with the ciliate—*Colpoda cucullus*—show that coarse sand retains 27,000 ; fine sand 185,000 ; soil and partially sterilised soil 270,000 and clay 450,000 per gram of material.

The importance of this work arises from the fact that some of the previous investigators have examined soil suspensions under the microscope for protozoa, and have drawn certain conclusions from failure to find active forms. The present investigation shows that the method is unreliable and the conclusions, therefore, not

https://doi.org/10.23637/ERADOC-1-109

justified. This objection does not apply to the dilution method described above.

XVIII. W. F. Bewley and H. B. Hutchinson. "*On the Changes through which the Nodule Organism (Ps. radicicola) passes under Cultural Conditions.*" Journal of Agricultural Science, 1920. Vol. X. pp. 144-162.

Under certain cultural conditions the nodule organism from the roots of red clover, broad bean, lucerne and lupin exhibits a tendency towards granular disintegration of the cell with the formation of small non-motile coccoid bodies, about 0.4μ diameter.

In the culture media ordinarily in use these coccoid bodies are not formed extensively, but cultivation on soil extract media rapidly leads to their production, until finally they constitute the predominant type in the culture.

A life-cycle consisting of five stages is described:—

1.—*The pre-swarmer form (non-motile).* When a culture of the organism is placed in a neutral soil solution, it is converted after four or five days into the pre-swarmer form.

2.—*Second stage, larger non-motile coccus.* In presence of saccharose, certain other carbohydrates and phosphates, etc., the pre-swarmers undergo a change. The original coccoid pre-swarmer increases in size until its diameter has been doubled, but still remains a non-motile coccus.

3.—*Swarmer stage, motile.* The cell then becomes ellipsoidal and develops high motility. This form is the well-known "swarmer" of Beijerinck.

4.—*Rod-form.* Proceeding in an "up-grade" direction, the swarmer becomes elongated and gives rise to a rod-form, which is still motile but decreasingly so. So long as there is sufficient available carbohydrate in the medium, the organism remains in this form.

5.—*Vacuolated stage.* When, however, the organism is placed in a neutral soil extract or the available carbohydrate becomes exhausted, it becomes highly vacuolated and the chromatin divides into a number of bands. Finally, these bands become rounded off and escape from the rod as the coccoid pre-swarmer.

The formation of the coccoid bodies (pre-swarmers) may also be induced by the addition of calcium or magnesium carbonates to the medium or by placing the organisms under anærobic conditions. Of a considerable number of compounds other than carbohydrates, calcium phosphate alone was capable of bringing about the change from pre-swarmers to rods.

The organism also appears to be affected greatly by the reaction of the soil. In the main, the normal rod rapidly changes into the pre-swarmer form in calcareous soils; acid soils cause the production of highly vacuolated cells and eventually kill the organism, while a slightly alkaline soil was found to be capable of supporting vigorous growth without altering the form of the cells.

The effect of various temperatures on the rapidity of pre-swarmer formation has been studied. Relatively high temperatures (30° and 37°) either prevent or postpone the entrance of down-grade changes.

XIX. H. B. HUTCHINSON and J. CLAYTON. "*On the Decomposition or Cellulose by an Aerobic Organism (Spirochæta cytophaga n. sp.).*" Journal of Agricultural Science, 1919. Vol. IX. pp. 143-173.

Examination of Rothamsted soils on different occasions has revealed the presence of an organism capable of breaking down cellulose with comparative ease. Morphologically, the organism appears to possess greater affinities with the Spirochætoideæ than with the bacteria, and the name *Spirochæta cytophaga* is therefore suggested.

While the Spirochæt is capable of considerable vegetative growth as a sinuous filamentous cell, it also appears to pass through a number of phases which terminate in the production of a spherical body (sporoid) which differs in a number of respects from the true spores of the bacteria. Germination of the sporoid again gives rise to the filamentous form, which possesses perfect flexibility and is feebly motile. The latter does not apparently possess flagella.

Spirochæta cytophaga is essentially aerobic; its optimum temperature is in the region of 30°. Both the thread and sporoid stages are killed by exposure to a temperature of 60° for ten minutes.

The nitrogen requirements of the organism may be met by a number of the simpler nitrogen compounds—ammonium salts, nitrates, amides and amino-acids. Peptone is also suitable in concentrations up to 0.025%. Stronger solutions, *e.g.*, 0.25% lead to a marked inhibition of growth. The organism fails to grow on the conventional nutrient gelatine or agar.

Comparative experiments with a number of higher alcohols, sugars and salts of organic acids show that none of these is capable of meeting the carbon requirements of the organism. Cellulose is the only carbon compound with which growth has been secured.

Although none of the monoses, bioses and other carbohydrates is able to support growth, many of them exert an inhibitive action on cellulose decomposition if present in other than very low concentrations. This may be correlated with the reducing properties of the carbohydrate. Maltose, for example, has been found to be approximately 70 times more toxic than saccharose.

Of the various by-products of the action of Spirochæta cytophaga may be mentioned: (*a*) a pigment possessing relations to the carotin group, (*b*) mucilage which does not give rise to optically active compounds on hydrolysis, and (*c*) small quantities of volatile acids.

Evidence is also adduced to show the relation of cellulose decomposition to the assimilation of atmospheric nitrogen.

XX. A. W. RYMER ROBERTS. "*On the Life History of Wireworms of the genus* AGRIOTES, *Esch., with some Notes on that of* ATHOUS HÆMORRHOIDALIS, F." Part I. Annals of Applied Biology, 1919. Vol. VI. pp. 116-135.

The biology and life history of the common "wireworm" was studied during the years 1916-1919. In England and probably also in Wales and Scotland, *Agriotes obscurus* is generally the commonest species. The adult beetles hatch from the pupa in August or September and remain in hibernation during the winter. About the middle of May they emerge, feed on the nectar or pollen of flowers and do little or no damage, at least in this country. Oviposition takes place generally from the end of June to the middle of July. The eggs of three species of *Agriotes—obscurus*, *sputator* and *sobrinus* and *Athous hæmorrhoidalis* were obtained from the soil of pots, in which the beetles had been confined, at depths varying from $\frac{1}{4}$-inch to 2 inches, either in batches or singly. Attempts to obtain ova from *Ag. lineatus* failed, but from other sources it is known to deposit its eggs in a similar position, and probably the presence of grasses, whether cultivated or growing as weeds, is essential to all five species. This conclusion points to the necessity for clean cultivation in the control of wireworms.

The larvæ on emergence at once burrow into the soil. All are pale in colour and so small (1-2.75mm.) as not to be generally recognised during their first year. The first moult of *A. obscurus* takes place in June, the second in July or August, and it is believed that the larvæ in general moult twice a year, in April or May, and again between July and September. In their first year, the larvæ appear to feed chiefly on partially decomposed vegetable matter and perhaps to some extent on the small roots of living plants, but no evidence of definite damage was obtained. In the later stages they feed on almost any crop and on many weeds. They appear to attack mustard only in the absence of more suitable food, though they are frequently found at the roots of charlock. The larvæ can subsist for a long time on the decaying organic matter in the soil and are able to withstand immersion in water for prolonged periods. During the winter they may be found close to the surface in grass land. But in fallow land they undergo a period of hibernation, sometimes as much as 2ft. from the surface.

Agriotes obscurus has a larval life history extending to five years, as was originally stated by Bierkander.

Pupation takes place in an earthen cell prepared by the larvæ at a depth of from 1 inch up to $7\frac{1}{2}$ or more inches. The pupal stage extends over a period of about 3 weeks, pupæ being found from the end of July to the middle of September.

Wireworms under natural conditions are not parasitized to any great extent. A Proctotrupid, probably *Phænoserphus fuscipes* Hal. was bred from *Athous hæmorrhoidalis*, and a Proctotrupid was also found within a larval *Agriotes obscurus*. The latter species was also found to be the host of a fungus of the genus *Isaria*.

XXI. F. Tattersfield and A. W. R. Roberts. *"The Influence of Chemical Constitution on the Toxicity of Organic Compounds to Wireworms."* Journal of Agricultural Science, 1920. Vol. X. pp. 199-232.

The relationship between chemical constitution and toxicity to wireworms of organic compounds is found to be of a two-fold nature.

The general effect of a group of compounds of the same type is directly determined by the chemical constitution of the type.

The particular effects of individual members of the groups are limited by their physical properties such as volatility, etc., which may be regarded as indirect consequences of their chemical constitution.

The aromatic hydrocarbons and halides are on the whole more toxic than the aliphatic hydrocarbons and halides. The groups that influence toxicity most when introduced singly into the benzene ring are in order of importance the methylamino (most effective), dimethylamino, hydroxy, nitro, amino, iodine, bromine, chlorine, methyl groups (least effective). But this order is modified in presence of another group; thus when there is a CH_3 already present in the ring the order becomes chlorine (side chain), amino, hydroxy, chlorine (ring), methyl. Chlorine and hydroxy groups together give rise to highly poisonous substances considerably more effective than where present separately. The association of chlorine and nitrogroups in chlorpicrin give rise to one of the most toxic substances tested. Methyl groups substituted in the amino group of aniline increase toxicity more than if substituted in the ring.

Compounds with irritating vapours have usually high toxic values, *e.g.*, Allyl isothiocyanate, chlorpicrin, benzyl chloride. The toxic values of these substances are not closely correlated with their vapour pressures or rates of evaporation.

There is a fairly close relationship between toxicities and the vapour pressure, rates of evaporation and volatilities of compounds of the same chemical type. In a series of similar compounds decreases in vapour pressure and volatility are associated with an increased toxicity. A possible explanation is that condensation or absorption takes place along the tracheal system when insects are submitted to the action of these vapours. On exposure once more to the open air these vapours diffuse out into the atmosphere, the rate at which they do so being a measure of the rapidity with which the insect recovers.

A limit is put upon toxicity by the decrease in vapour pressure, when it sinks too low to allow a toxic concentration in the vapour phase. Chemically inert compounds boiling above 170° C. are generally uncertain in their poisonous effects on wireworms after an exposure of 1,000 minutes at 15° C. Nearly all organic compounds boiling above 215° C. are uncertain in their action, while those boiling above 245° C. are non-toxic. These limits depend on the resistance of the insect, the length of exposure and the temperature at which the experiment is carried out.

XXII. N. N. Sen Gupta. "*Dephenolisation in Soil.*" Journal of Agricultural Science, 1921. Vol. XI.

It is found that phenol and the cresols disappear when added to soil. Three actions seem to be involved :—

1.—An instantaneous disappearance which appears to be non-biological, but its exact nature has not yet been elucidated; apparently it varies directly with the clay content of the soil.

2.—A slow decomposition which continues till all the phenol is exhausted. This is apparently largely brought about by micro-organisms capable of utilising phenol as a source of energy.

https://doi.org/10.23637/ERADOC-1-109

3.—There appears, however, to be some non-biological slow decomposition also, since the decomposition in unmanured soil poor in micro-organisms is much slower than in manured soils, and altogether different in character.

Autoclaving the soil at 130° for 20 minutes destroys the cause or causes of the decomposition altogether, but the action proceeds, although much more slowly, than in untreated soil, in the presence of a considerable amount of toluene and mercuric chloride.

Partial sterilisation by treatment with toluene which was evaporated before the addition of phenol increases the rate of decomposition, but steaming does not.

The decomposition takes place even in soil air-dried to 2.4% moisture, but it is extremely slow compared with the rate in normal soil.

When successive doses of phenol are applied to the same soil, each dose is decomposed at a higher rate than the preceding one. This is entirely in accordance with a decomposition mainly biological in character. The same effect has been observed in the case of *m*-cresol.

The treatment of the soil with sulphuric acid (50% by volume) either before or after the addition of phenol greatly augments the instantaneous loss, which may amount to 90% in case of phenol This loss is not affected by autoclaving.

CONDITIONS DETERMINING ENVIRONMENTAL FACTORS IN THE SOIL.

XXIII. B. A. KEEN. "*A Note on the Capillary Rise of Water in Soils.*" Journal of Agricultural Science, 1919. Vol. IX. pp. 396-399.

A simple formula for the theoretical maximum rise in an ideal soil, composed of closely packed and uniform spherical grains, may be obtained from a consideration of the triangular pores existing in such a soil. The formula reduces to $h = \frac{.75}{r}$ where h = height of rise and r = radius of spherical grain. The capillary rises given in the following table are calculated on the assumption that a soil is made up entirely of one given soil fraction, and not of a mixture of fractions, and the particles are taken as closely packed spheres :—

Soil Fraction	Diameter in mm.		Capillary Rise in cms.		Average Rise in Ft.
	Max.	Min.	Min.	Max.	
Fine gravel .	3	1	5	15	$\frac{1}{3}$
Coarse sand .	1	.2	15	75	$1\frac{1}{2}$
Fine sand .	.200	.040	75	375	$7\frac{1}{2}$
Silt . . .	.040	.010	375	1500	$31\frac{1}{4}$
Fine silt . .	.010	.002	1500	7500	150
Clay . .	.002	—	7500	—	150 upwards

https://doi.org/10.23637/ERADOC-1-109

XXIV. B. A. KEEN. "*A quantitative Relation between Soil and the Soil Solution brought out by Freezing-point Determinations.*" Journal of Agricultural Science, 1919. Vol. IX. pp. 400-415.

An analysis is made of the experimental data accumulated by Bouyoucos and others in their investigations of the freezing-point depression of the soil solution *in situ* under various conditions. Bouyoucos finds that the soil solution in quartz sand and extreme types of sandy soil behaves approximately like dilute solutions, the freezing-point depression varying as the concentration, or, in the present case, inversely as the moisture content, *i.e.*,

$$M_n D_n = K$$

where K = constant, D_n = freezing-point depression at moisture content of M_n. In the vast majority of soils, however, the freezing-point depression increases much more rapidly with decreasing moisture content than this equation would imply, and Bouyoucos was led to suppose that the soil rendered a definite amount of water "unfree," in the sense that it did not take part in the freezing-point depression.

This hypothesis is quantitatively examined in the present paper, and it is shown from Bouyoucos' experimental data that :—

1.—The water rendered unfree is not a constant amount, but varies with the moisture content.

2.—A definite relation exists between the free, unfree and total moisture, expressed by the equations :—

$$Y_n = cM_n^x$$

$$Z_n = \frac{1}{c^{\frac{1}{x}}} Y_n^{\frac{1}{x}} - Y_n$$

where c and x are constants for any one soil,

M_n = total moisture content,
Y_n = free water,
Z_n = unfree water.

XXV. B. A. KEEN. "*The Relations existing between the Soil and its Water Content.*" Journal of Agricultural Science, 1920. Vol. X. pp. 44-71.

This paper is a general survey of the literature of the subject. Until recently, most of the experimental data was interpreted on the assumption that the moisture was distributed in a thin film over the surface of the soil grains. The water in this film was divided into three classes: hygroscopic, capillary and gravitational. The gravitational water could drain away into the subsoil, the capillary water was retained by the soil, and was capable of movement therein, and the hygroscopic moisture was assumed to be incapable of movement under capillary or gravitational forces.

It was found that these divisions were insufficient to explain the observed facts, and a number of auxiliary divisions and equilibrium points were introduced, mainly by American workers. This carried with it the serious defect that each sub-section was more or less detached from its neighbours, and thus the hypothesis did not give a complete picture of the *continuous* processes operating between soil and its moisture content when the latter varied over wide limits. Endeavours were therefore made to link up the sub-divisions by means of cross-relations between the variables, but they were mainly applicable over some small range of moisture content or to some approximate equilibrium values.

The development of the study of colloids rendered it possible to consider the relations between soil and its moisture content by an alternative hypothesis which would stress their continuous nature. It is now considered that the soil particles are coated with a colloidal complex, derived from the clay and the organic matter. In the concluding section of the paper a number of investigations are considered and interpreted on this hypothesis, and some of the most promising future lines of work are indicated.

XXVI. B. A. Keen. "*The Physical Investigation of Soil.*" Science Progress, 1921. Vol. XV. pp. 574-589.

This is a general account of the scope of physical science in investigations on soil. It deals with the dimensions of soil particles and the manner of their arrangement in the soil, the temperature, moisture, and atmospheric relations in the soil, and indicates also the great need for research on methods of cultivation and the effect on the soil of the form of implement used, in view of the important changes in farming practice brought about by the introduction of the tractor.

XXVII. B. A. Keen and E. J. Russell. "*The Factors determining Soil Temperature.*" Journal of Agricultural Science, 1921. Vol. XI.

The purpose of this paper is to discuss the factors influencing soil temperature and the extent to which other measurements (air, temperature, hours of sunshine, etc.) can be utilised in cases where direct determinations of soil temperature are not made.

An analysis has been made of one year's records given by a special recording thermometer embedded at the 6in. depth in bare soil, together with continuous records of air temperature and hours of sunshine; these have been supplemented by daily readings of rainfall, radiation, and soil temperature at the 12in. depth. The extent of the temperature rise at the 6in. depth is largely determined by the amount of solar radiation reaching the earth's surface (correlation co-efficient .877 $\pm$ .009). As would be expected, the hours of sunshine also provide a good measure of this radiation.

The maximum temperature at the 6in. depth during the summer months is about equal to that of the air, and the minimum temperature is from 6°—8° C. higher than the air minimum.

During this period, the conditions therefore resemble those in a 20° C. incubator.

In the winter months the minimum temperature at the 6in. depth is usually about 2°—3° C. higher than that in the air, and the maximum temperature is a little below the maximum air temperature. The effect of rainfall is generally to diminish the rise of temperature, but the relation is by no means exact. No evidence was found supporting the belief that spring rains warm the soil; on the other hand, autumn rains apparently prevent the soil from cooling as much as it would otherwise have done.

There is no satisfactory substitute for a recording soil thermometer, but a fair estimation of the mean daily temperature at the 6in. depth can be obtained over the greater part of the year by regarding the maximum air temperature as the maximum soil temperature, and the 12in. depth soil temperature at 9 a.m. as the minimum, and then taking the mean.

The relations between the daily temperature rise in the soil and the air have been studied in detail by following the changes in the ratio $\frac{\text{soil amplitude}}{\text{air amplitude}}$ from day to day. These ratios fall into a well-defined frequency curve whose maximum occurs between the values .2—.3. This range of the ratio is prevalent in spring and early summer, and also in early autumn. A similar curve is given by the ratios of the daily cooling of soil and air, the maximum in this case being between .3—.4. The ratio $\frac{\text{soil amplitude}}{\text{air amplitude}}$ of course alters when either, or both, numerator and demominator change. A series of relations between these changes, both for individual and averaged values is given in the paper.

XXVIII. E. A. Fisher. "*Studies on Soil Reaction—I. A résumé.*" Journal of Agricultural Science, 1921. Vol. XI. pp. 19-44.

A critical account of the various hypotheses put forward to explain the phenomena of soil acidity and the methods that have been suggested for estimating it. All present methods are shown to be defective. The hydrogen ion concentration gives useful indications, but the titration methods, lime requirement methods, etc., are defective because the lime requirement is really very complex, being made up of two factors; the lime required to neutralise soil acids, and the lime actually absorbed by the soil. It is impossible at present to differentiate these or to compare with any degree of strictness one soil or one base with another.

XXIX. E. A. Fisher. "*Studies on Soil Reaction—II. The colorimetric determination of the hydrogen ion concentration in soils and aqueous soil extracts.*" Journal of Agricultural Science, 1921. Vol. XI. pp. 45-65.

Details to be observed and difficulties to be overcome in the colorimetric determination of the hydrogen ion concentration in soils. It is shown that the fineness of division of the soil is of considerable importance.

PLANT PATHOLOGY.

XXX. A. D. Imms and M. A. Husain. "*Field Experiments on the Chemotropic Responses of Insects.*" Annals of Applied Biology, 1920. Vol. VI. pp. 269-292.

During the course of these experiments the insects attracted consisted almost exclusively of *Diptera; Hemiptera, Coleoptera* and *Neuroptera* were unrepresented. A small number of *Noctuid Lepidoptera* entered the traps, which however were not adapted for such relatively large insects as many *Lepidoptera*. Beer, cane molasses, and mixtures of these two substances are powerful chemotropic agents for various *Diptera*. Ethyl alcohol, in various concentrations, exhibited little or no chemotropic properties, but with the addition of small amounts of butyric, valerianic or acetic acids it exercised a powerful attraction. Aqueous dilutions of the above acids were not attractive, the respective esters probably being the attractive agents in each case. The remaining substances utilised in these experiments were found to exhibit little or no positive chemotropic properties. Out of considerably over 3,000 *Diptera* attracted during the course of these observations, by far the greater number pertained to one or other of the five families, *Rhyphidæ, Mycetophilidæ, Sepsidæ, Muscidæ* and *Anthomyidæ*. As a general rule, members of both sexes of a species were attracted irrespective of the chemotropic agent employed. In the majority of instances, males predominated over females, but in no case where the number of individuals of a species attracted exceeded 20 was the disproportion greater than 2.9 males to 1 female. *Rhyphus punctatus, Hylemyia strigosa* and *Calliphora erythrocephala* were the dominant species attracted.

XXXI. J. DAVIDSON. "*Biological Studies of Aphis rumicis L.*" Part I.—"*Description of the Species and Life History.*" Bull. Entom. Res., Vol. XI., 1921.

"*Biological Studies of Aphis rumicis L.*" Part II.—(a) "*Appearance of the Winged Forms*"; (b) "*Appearance of the Sexual Forms.*" Proc. Roy. Dublin Soc., 1921.

"*Biological Studies of Aphis rumicis L.*" Part III.—(a) "*Reproduction of Aphis rumicis on different Host Plants*"; (b) "*Influence of Food Plants on the Characters of the Species*"; (c) "*Influence of Temperature and Humidity on the Development of the Species.*" Annals of Applied Biology, Vol. VIII., 1921.

The life history of *Aphis rumicis* is as follows :—

The ova are laid by sexual females on the winter host *(Euonymus)* during September and October [1]. These hatch out in March and April, and the *Fundatrices* produce the first viviparous generation on the winter host. Eventually, w.v.[2] (*migrantes*) develop, which migrate to the intermediate hosts, such as beans, poppies, etc. On these latter plants, they produce a.v. (*alienicolæ apteræ*). Eventually, w.v. (*alienicolæ alatæ*) are produced which fly to other intermediate hosts, of the same kind or different species, such as *Chenopodium*, Mangolds, Beet, *Capsella bursa-pastoris*, *Rumex*, etc. This infestation of the intermediate hosts continues throughout the summer months.

In September, certain of the *alienicolæ apteræ (sexuparæ apteræ)* produce winged sexual males, and at the same period certain of the *alienicolæ alatæ (sexuparæ alatæ)* which morphologically resemble the earlier winged forms but are physiologically different, fly back to the winter host, and there produce apterous females. The males fly back from the intermediate hosts to the winter hosts, the cycle being thus closed.

(1) It is highly probable considering the wide distribution of *Aphis rumicis* that there are other winter hosts.

(2) w.v.—winged viviparous female: a.v.—apterous viviparous female

Experimental evidence indicates that the sequence of winged and apterous agamic females is largely due to some internal inherent tendency. w.v. tend to produce a.v. and a.v. may produce entirely a.v. or a mixed progeny, consisting of a variable percentage of winged forms. The apterous condition is to be regarded as an adaptation, over a long period of time, to seasonal food and temperature conditions.

The appearance of sexual forms in the experiments—especially having regard to the cytological investigations in Aphids—shows that the change from the viviparous parthenogenetic phase to the sexual phase is doubtless associated with the chromozome complex, and not primarily due to food and temperature changes.

The agamic generations appear to be interpolated between the winter egg and the sexual generations as an adaptation to seasonal conditions.

Certain a.v. may produce agamic forms as well as sexual forms. In some cultures which were kept in a greenhouse, a.v. and *sexuparæ alatæ* (mothers of the oviparous females) developed in every generation throughout winter from September to April.

The degree of infestation for different species of plants varies considerably. Thus, experimenting with several plants of the same kind, the maximum total number of aphids produced from one a.v. over a 14-day period, for each kind of plant, is shown in the table below :—

Kind of Plant	Total number of aphids in 14 days.	
	1914 Germany	1920 Rothamsted
Broad Beans . . .	1192	1290
Field Beans . . .	1259	—
Sugar Beet . . .	696	294
Red Beet . . .	546	197
Mangolds	534	201
Peas	200	—
Rumex	252	—
Poppies	243	193

The higher figures obtained in Germany on Sugar Beet, Red Beet and Mangolds, suggests a local adaptation of the species to these food plants. Owing to other factors however, especially temperature, it is difficult to draw fine conclusions from any two series of experiments not carried out under the same experimental conditions.

The relative susceptibility of different varieties of Broad Beans was tested in 1920. Ten varieties were taken and 5 plants of each variety were infected with one a.v.

The average numbers of aphids produced from one a.v. on the 5 plants of each variety over a 14-day period were :—

No. of Variety.	1	2	3	4	5	6	7	8	9	10
Average No. of aphids.	897	1018	813	925	840	858	777	1099	746	1000

The results show that the infestation is slightly less on some varieties than on others. These varieties are, however, too closely related racially, to give striking differences, and the experiments are being continued with other varieties of Beans.

Further investigations are in hand dealing with the effect of the manurial treatment of crops on the degree of the infestation of plants by aphids; the relations between the varying constitution of the cell sap of plants, the food of aphids, and the infestation of plants by them, and the working of the stylets in relation to the cells of plant tissues.

XXXII. W. B. Brierley. "*Some Concepts in Mycology—an attempt at Synthesis.*" Trans. British Mycological Society, 1919. Vol. VI. (part ii.). 204-235.

The paper is divided into two parts which, however, are mutually dependent—the species concept and the concept of the educability of fungi. In the former the thesis is maintained that the morphological characters of an organism are a function of the particular genotype and the environmental conditions, and that the phenotypes of different organisms converge or diverge in constant and definite relation to the physico-chemical factors of the environment. Thus morphological characters are no true criterion of specificity. It is further maintained that the only exact method of species creation and specific determination is by means of quantitative physiological data derived from pure cultural treatment under standardised physico-chemical conditions. In the second part the thesis is put forward that the genotypes of "pure lines" of bacteria and fungi are constant and ineducable, and that genotype changes which have been described are better interpreted in terms of modification, of the selection of strains from a population, of stages in a complex life-cycle, or of segregation from a genetically impure ancestor.

XXXIII. W. B. Brierley. "*On a Form of Botrytis cinerea, with Colourless Sclerotia.*" Phil. Trans. Royal Society of London, 1920. Series B. Vol. 210. 83-114.

The fungus, *Botrytis cinerea,* produces black sclerotia, but in a single spore pedigree culture a colourless sclerotium was formed, which gave rise to a strain having colourless sclerotia. This character proved to be constant. The origin and relationships of this new strain are examined and a comparison made of the morphology and physiology of the colourless derivative with the parent. It is shown that the only apparent character in which the two strains differ is in the absence of pigment in the sclerotial skin.

The nature of the loss of colour is considered in relation to the biochemistry and genetics of albinism. The significance of the colourless form is discussed and the hypothesis brought forward that this and other genotypic changes among fungi are better interpreted in terms of segregation from a genetically impure parent than as true mutations. The possibilities of genetic contamination in sexual and asexual fungi are considered.

XXXIV. W. B. Brierley. "*Orchid Spot Disease.*" Gardeners' Chronicle, 1919. Vol. LXV. No. 1676.

A consideration of the several diseases of orchid leaves included under the name " Orchid Spot " ; with notes on methods of treatment.

XXXV. J. Henderson Smith. "*The Killing of Botrytis Spores by Phenol.*" Annals of Applied Biology, 1921. Vol. VIII. No. 1.

It is shown that if *Botrytis* spores be exposed to the action of 0.4 per cent. phenol, the spores do not all die simultaneously, but some die in a few minutes and some not till two or three hours have elapsed. The curve showing the numbers surviving at different times has a sigmoid shape. If the strength of phenol be progressively raised, the curve becomes less and less sigmoid, approaching the logarithmic type of curve. With the same suspension it is possible to obtain either a logarithmic or a sigmoid curve according to the strength of phenol used. Both types of curve are shown to be explicable on the assumption that the individual spores differ in resistance and that a frequency curve showing the distribution in the resistance grades approaches the normal curve. The influence of the number of spores used is shown to be very considerable; and the consecutive transition from the sigmoid to the logarithmic type occurs, whether we raise the phenol strength, keeping the spore number constant, or reduce the spore number keeping the phenol constant, or use younger and younger spores.

TECHNICAL PAPERS.

CROPS AND CROP PRODUCTION.

XXXVI. Winifred E. Brenchley. "*Useful Farm Weeds.*" Journal of Board of Agriculture, 1918. Vol. XXV. pp. 949-958.

During the war the deficiency in supplies of every kind led to a revival of interest in the uses to which many farm weeds can be applied. If the need ever became sufficiently urgent, weeds might serve many useful purposes, but with the restoration of more normal conditions most of them have again fallen into disuse.

Weeds have their uses in medicine, as dyes, manures, and as fibre plants, but in times of stress they are most valuable as fodder and human food. Couch grass, spurry, bent grass, nettles, chicory, gorse and poppy cake can all serve as fodder, especially as most of them, in addition to being nutritious, are obtainable in large quantities.

Chicory and " salep " *(Orchis mascula)* are the principal weeds used as human food. Chicory has long been employed as a substitute or adulterant for coffee, while salep enters largely into the diet of people of Turkey, Persia and Syria. Many weeds provide leaves that have been used as substitutes for tea and coffee, and the young tops of nettles, garlic and dandelion have been frequently used as green vegetables by country folk.