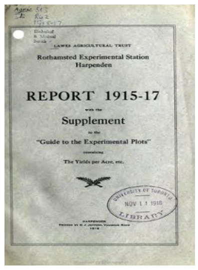
Report 1915-17 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



Soil Problems

Rothamsted Research

Rothamsted Research (1917) *Soil Problems ;* Report 1915-17 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 22 - 27 **- DOI: https://doi.org/10.23637/ERADOC-1-108**

PAPERS PUBLISHED.

SOIL PROBLEMS.

I. "*The Atmosphere of the Soil: its Composition and the Causes of Variation.*" E. J. Russell and A. Appleyard. Journal of Agricultural Science, 1915. 7, 1-48.

The free air in the pores of the soil to a depth of six inches is very similar in composition to the atmospheric air, but it differs in two respects :

(*a*) It contains more carbon dioxide and correspondingly less oxygen, the average in 100 volumes being 0.25 volumes of carbon dioxide and 20.6 of oxygen against 0.03 volumes of carbon dioxide and 20.96 of oxygen in atmospheric air.

(*b*) It shows greater fluctuation in composition.

Usually the sum of the carbon dioxide and oxygen is only slightly less than in atmospheric air, but at periods when nitrates rapidly increase there is a perceptible falling off of oxygen, and a still greater one in waterlogged soils.

Besides this free air there is another atmosphere dissolved in the water and colloids of the soil. This consists mainly of carbon dioxide and nitrogen and contains practically no oxygen.

The fluctuations in composition of the free soil air are mainly due to fluctuations in the rate of biochemical change in the soil, the curves being similar to those showing the amount of nitrate and the bacterial counts as far as they were taken. The rate of biochemical activity attains a maximum value in late spring and again in autumn, and minimum values in summer and winter. In autumn the bacteria increase first, then the carbon dioxide rises, and finally the nitrate increases.

From November to May the curves closely follow those for the soil temperature which thus appears to be the dominating factor ; from May to November they follow the rainfall and to a less extent the soil moisture curves. The difference between rainfall and soil moisture indicates that rainfall does something more than add water to the soil. It is shown that the dissolved oxygen brought in is probably a factor of considerable importance in renewing the dissolved soil atmosphere and facilitating biochemical change.

Grass land usually contains more carbon dioxide and less oxygen than arable land, but we cannot attribute the difference wholly to the crop owing to the large differences in soil composition and conditions. It is difficult to ascertain the precise effect of a crop, but as the soil differences are eliminated so the differences in composition of the soil air becomes less and less. No evidence could be obtained that the growing crop markedly increases the amount of carbon dioxide in the soil air ; if it gives rise to any great evolution of carbon dioxide in the soil it apparently exercises a correspondingly depressing effect on the activities of soil bacteria. This result agrees with one obtained earlier in reference to the nitrates in the soil.

Such weather conditions as barometric pressure, wind-velocity, variations in temperature from the mean, small rainfall, etc., seem to have but little effect on the soil atmosphere.

II. "*The Influence of Soil Conditions on the Decomposition of Organic Matter in the Soil.*" E. J. RUSSELL and A. APPLEYARD. Journal of Agricultural Science, 1917. **8**, 385-417.

The changes in bacterial numbers and in nitrate content of the soil and in carbon dioxide content of the soil air were determined at frequent and regular intervals during several seasons on five different plots of land, and the results are set out on curves.

There is sufficient resemblance between the curves for bacterial numbers, carbon dioxide (except for a period on cropped land), and nitrate content to justify the conclusion that they are all related.

The curve for nitrates, however, is always behind that for bacterial numbers, the lag amounting to two or three weeks. Assuming that the curves are connected, this would indicate two stages in nitrate production: one related to the bacterial numbers, the other not. Evidence is brought against the view that the stages are simply ammonia production and then nitrate production; the division has apparently to be carried further back and ammonia production to be divided into two stages.

The biochemical decompositions in the soil are determined in the first instance by the temperature and do not proceed to any notable extent below 5° C.

As soon as the temperature rises in spring, action takes place rapidly. But it soon slows down and other factors begin to operate.

Moisture is one of them. Action came to a minimum in June, when the moisture fell to 10 per cent. by weight of the unmanured soil and 15 per cent. by weight of the dunged soil, or 16 and 22 parts respectively by volume, assuming there was no contraction.

Rainfall is an even more important factor, a shower of rain having a notable effect in starting the decompositions. It seems probable that the dissolved oxygen plays an important part here.

The growing crop exerts a depressing effect, though whether by taking up the dissolved oxygen, giving out carbon dioxide, or some other action is not clear.

The fluctuations in bacterial numbers are not wholly explicable as functions of the temperature and moisture content. Some of the rises and falls are of the kind obtained during the investigations on partial sterilisation; further work on this problem is in hand in our laboratories.

III. "*Dissolved Oxygen in Rain Water.* ERIC HANNAFORD RICHARDS. Journal of Agricultural Science, 1917. **8**, 331-337.

Rain water was collected in a special form of apparatus, and the amount of dissolved oxygen was determined by Winkler's method on each occasion when 0.3 inches or more fell—this being the lowest rainfall that gave sufficient liquid for the analysis. During autumn, winter and spring, when the temperature was below 15° C., the rain was practically saturated with oxygen, the quantities found being on an average 93 per cent. of Dittmar's complete saturation values for distilled water. Rain collected in summer, however, was less saturated, the amount of oxygen being 85 per cent. of the full saturation value. The difference was carefully examined and found to be real; it is not an accident of the method of collection. It is difficult to understand why the summer rain should contain less oxygen than rain falling in the rest of the year, especially in view of the circumstance that the relative temperatures of the rain clouds and of the air at ground level ought to cause super-saturation in summer and not under-saturation.

The significance of the dissolved oxygen in the soil is discussed.

IV. "*Methods for the Examination of Soil Protozoa.* CHARLES HENRY MARTIN and KENNETH R. LEWIN. Journal of Agricultural Science, 1915. **7**, 106-119.

Descriptions are given of some of the organisms isolated in the trophic state by the two methods already described (Annual Report for 1914, page 19). Amœbæ and thecamœbæ were most frequently met with ; ciliates and flagellates* were relatively rare.

The organisms described are *Euglypha* and *Chlamydophrys* among the thecamœbæ ; *Chilodon*, a ciliate ; *Vahlkampfia soli*, a limax amœba, *Amœba gobaniensis* and *Amœba cucumis*, lamellipodian amœbæ, and *Boda caudatus*, a flagellate ; all these had been found in the trophic state in the soils examined.

V. "*Soil Protozoa and Soil Bacteria.*" E. J. RUSSELL. Proceedings of the Royal Society, 1915. **89**, 76-82.

The experimental evidence of the existence in soil of a living protozoan fauna in the trophic, as distinct from the encysted, state is collected. The fauna is shown mainly to consist of flagellates, amœbæ and thecamœbæ ; ciliates only being present in smaller numbers, and probably for the most part in the encysted form. This conclusion is in harmony with Goodey's work, and with all the facts at present ascertained.

VI. "*The Utilisation of Organic Residues for Nitrogen Fixation and the Losses of Nitrogen from the Soil.*" HENRY BROUGHAM HUTCHINSON. Journal of Agricultural Science, 1918. **9**, 92-111.

It has long been known that appreciable quantities of gaseous nitrogen may be assimilated from the atmosphere when a soil or a culture of a soil organism (*Azotobacter chroococcum*), is supplied with soluble carbohydrates under laboratory conditions. The present paper shows that this action also occurs under natural conditions, and that plant residues can be utilised for nitrogen fixation in the laboratory and in pot experiments. Crop increases may also be obtained when field soils are treated with an easily oxidisible carbohydrate such as sugar, and these may be attributed to the assimilation of atmospheric nitrogen.

The effect of carbohydrates and of plant residues on the soil is shown to be complex, and under certain conditions—when the soil temperature is low, or when the applications are made too near to the time of sowing—marked depression of the crop may occur. This effect appears to be largely due to destructive processes, which result in a withdrawal of available nitrogen compounds or a loss of free nitrogen from the soil.

*Subsequent work has shown that amœbæ and thecamœbæ are much more numerous than ciliates, though, as a matter of fact, the flagellates are often more numerous still—not less so as these earlier observations suggested.

VII. "*The Non-Persistence of Bacterio-Toxins in the soil.*" HENRY BROUGHAM HUTCHINSON and AAGE CHRISTIAN THAYSEN. Journal Agricultural Science, 1918, **9**, 43-62.

It has been claimed by other workers that the phenomena of partial sterilisation of soil are due, in part, to the destruction of bacteric-toxins when a soil is subjected to heat. The experiments on which this conclusion is based were, therefore, repeated and extended; in particular, a comparison was made of the growth of a test organism—*B. prodigiosus*—when inoculated into an extract of untreated soil and into a similar portion of extract which has been heated with the object of destroying any toxins present. The results obtained with six normal English soils show that the initial depression occurring when a culture is carried into an extract of untreated soil is not due to the action of toxic substances in the extract, as has been assumed by other experimenters, but is more probably a starvation effect. When these extracts were subjected to heat, their suitability for growth was still further reduced, but the addition of minute quantities of peptone was sufficient to convert them into media suitable for active growth.

The only extract which showed improvement on boiling was that of a very acid soil, but in this case the observed toxicity appears to be connected with the presence of acid iron and aluminium compounds, which are liberated by the action of neutral salt solutions, but thrown out of action when the extracts are heated.

VIII. "*The Reaction between Dilute Acids and the Phosphorus Compounds of the Soil.*" E. J. RUSSELL and JAMES ARTHUR PRESCOTT. Journal of Agricultural Science, 1916. **8**, 65-110.

This reaction is of great importance in soil analysis, as it forms the basis of the methods for determining the amount of phosphate "available" in the soil for the plant. In studying this reaction in the laboratory it was found to throw important light on the constitution of the soil.

When soil is shaken with a dilute acid a certain amount of phosphoric oxide (P_2O_5) is dissolved, the quantity depending on the particular acid and the conditions of the reaction. Under similar conditions the amount varies widely with different acids, being greatest with citric and oxalic acids, which are usually regarded as weak acids, and least with hydrochloric and nitric acids, the strong acids. The investigation cleared up this anomaly.

It was shown that the action is really complex; two changes are proceeding simultaneously, a direct and a reverse action, and the observed result is the difference between the two.

When soil is shaken with a dilute acid some of the phosphorus compounds go into solution, and the amount dissolved by different acids at equivalent concentrations is much the same; nitric, hydrochloric and citric acids give the same results; sulphuric acid gives a somewhat higher result.

A reverse reaction at once sets in, however. Some of the phosphoric oxide is withdrawn from the solution in spite of the presence of excess of acid. The process is an ordinary adsorption and obeys the usual law expressed by the equation $y=Kc^{\frac{1}{p}}$. Its extent varies with the different acids; it is much more marked in the presence of nitric than of citric acid.

The amount of phosphoric oxide actually determined by the analyst is, therefore, not the true amount dissolved, but the difference between these two wholly different actions.

It is now obvious why the amount of "available Phosphoric Oxide" determined by extraction with dilute acids shows such great variations in different methods of analysis and so little correlation with the actual quantities obtainable by the crop. In no case do they stand for any single quantity, but only for a difference between a direct action and an adsorption which varies with the nature of the acid and the conditions of the experiment.

So long as they are confined to the same type of soil, however, any of the acids investigated would have given useful results, but difficulties would arise directly an attempt was made to compare dissimilar soils. The proper way to use a soil analysis is in conjunction with a soil survey.

A diffusion method is described in which the reverse reaction is eliminated and which therefore gives a true measure of the direct action. But until we have had more experience with it we are not prepared to say what value it has for soil analysis.

IX. "*The Phenomenon of Adsorption in its Relation to Soils.*" James Arthur Prescott. Journal of Agricultural Science, 1916. **8**, 111-130.

A résumé of the subject in which the voluminous literature is critically examined and summarised. Several directions are indicated in which more investigations are needed.

X. "*Note on the loss of Phosphoric Acid during Fusion with Ammonium Fluoride.* W. A. Davis and J. A. Prescott. Journal of Agricultural Science, 1916. **8**, 136-138.

Considerable loss of phosphoric acid may occur when salts or minerals containing this substance are ignited with ammonium fluoride in the ordinary process of analysis of silicates. It seems possible that the phosphorus is volatilised as a fluoride. The loss is least in the case of salts containing an alkali metal, but is greater for phosphates of the alkali earth metals, such as apatite and other calcium phosphates.

XI. *The Recovery of Ammonium Molybdate used in phosphate Estimations.* J. A. Prescott. The Analyst, 1915. **40**, 390-391.

The mixed residues are acidified if excess of acid is not already present and evaporated to small bulk. The yellow precipitate of molybdic acid which separates is filtered off, washed with cold water, dissolved in ammonia and freed from phosphoric acid by means of magnesia mixture. The filtered solution is concentrated, keeping ammonia present in excess, and allowed to crystallise.

If the solution is blue owing to the presence of lower oxides of molybdenum it is treated with hydrogen peroxide.

XII. "*Studies of the Lime Requirements of Certain Soils.* Henry Brougham Hutchinson and Kenneth MacLennan. Journal of Agricultural Science, 1915. **7**, 75-105.

https://doi.org/10.23637/ERADOC-1-108

Two different effects of lime are studied, its sterilising action and its power of neutralising acidity. Sterilisation is effected when so much lime has been added that an aqueous extract of the soil is alkaline to phenolphthalein; chemical, bacteriological and physiological tests all closely agree. This can be effected by lime only; the carbonate is of no use for the purpose.

Neutralisation, however, requires much less lime, and can equally be brought about by the carbonate. The amount necessary is indicated by the adsorptive capacity of the soil for calcium bicarbonate.

A definite connection was traced between soil reaction and natural flora on soils of the same type and similarly situated; for example, in making a close survey of Harpenden Common the following plants were dominant in patches of differing lime requirements, clover appearing only where the need for lime was small, Yorkshire fog and finally sorrel where the need was great :—

LIME REQUIREMENTS AS RELATED TO VEGETATION.

Average Lime requirement of Soil.	Dominant Flora.
Approx. 0.22% $CaCO_3$	*Trifolium repens* (wild white clover)
,, 0.26% ,,	*Festuca ovina and rubra*
,, 0.31% ,,	Mixed. *Achillea Millefolium*, *Luzula* and moss.
,, 0.39% ,,	*Ulex europæus* (gorse)
,, 0.43% ,,	*Holcus lanatus* (Yorkshire fog)
,, 0.53% ,,	*Rumex Acetosa* (sorrel)

XIII. "*The Effect of Removing the Soluble Humus from a Soil on its Productiveness.*" William Weir. Journal of Agricultural Science, 1915. 7, 246-253.

A large quantity of soil was divided into two portions; one was treated with dilute hydrochloric acid and repeatedly extracted with dilute caustic soda solution so as to remove soluble humus; the other was left untouched. Chalk was added to the treated soil to make the carbonate content equal to that of the untreated soil; the soils were then put into pots and sown with four crops in succession: wheat, mustard, rye, and finally mustard again. In each case the yields, both of dry matter and of nitrogen, were approximately the same for the untreated and the treated soils, in spite of the circumstance that the extraction had removed 40 per cent. of the nitrogen from the soil.

Laboratory experiments were also made to ascertain the effect of the extraction on the production of ammonia and nitrates in the soil. It was found that the extraction increased the bacterial numbers and ammonia accumulation, but diminished nitrate production, though the sum of ammoniacal and nitric nitrogen is usually less in the extracted than in the untreated soil. These results agree with those obtained by W. Buddin, when soils were treated with non-volatile antiseptics (Report for 1914, p. 12), and they suggest that one result of the extraction process is partially to sterilise the soil.