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ROTHAMSTED
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Report for 1931

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Bacterial Numbers and Soil Fertility

Rothamsted Research

Rothamsted Research (1932) *Bacterial Numbers and Soil Fertility* ; Report For 1931, pp 40 - 41 -
DOI: <https://doi.org/10.23637/ERADOC-1-65>

Somewhat different methods are used in the United States.

In order to make a careful study of these, one of their leading soil surveyors, L. L. Lee of the New Jersey Experimental Station, was invited to visit Rothamsted for a year during which time he made two typical surveys: a detailed survey of the Rothamsted farm, showing how the methods are used in making an intensive survey of a small area, and a more general survey of Kent, showing how they deal with a large area in a limited space of time. A number of meetings took place with soil surveyors in this country, out of which emerged agreements as to procedure which will prove of great value for future work. One of the German "Kulturtechniker" Dr. Janert, was also invited here for a year to apply his heat of wetting and other methods to the study of British soils.

GENERAL MICROBIOLOGY

Much of the earlier work of the Station was concerned with the effects of partial sterilisation of soil, and the view was expressed that the increased numbers of bacteria following on the partial sterilisation treatment resulted from the suppression of soil protozoa. This has been confirmed by much subsequent work and regular relationships have been traced between the numbers of bacteria and those of protozoa; when one is high the other is low, and *vice versa*.

The further deduction was made that these higher numbers of bacteria produced a larger amount of ammonia in the soil and therefore increased the total amount of plant food. It now appears that this requires important qualification; the amount of ammonia and carbon dioxide produced does not increase proportionately to the numbers of bacteria, but much less. As the bacterial numbers increase so their individual efficiency decreases. In experiments with cultures of bacteria in artificial media it was shown that additions of the protozoa *Colpidia* reduced the bacterial numbers, and increased the individual efficiency. The relationships between numbers and efficiency could be expressed by a straight line, but the actual line for the protozoa-free cultures differed from that expressing the results for the cultures containing protozoa in a way suggesting that *Colpidium* stimulated ammonia production by the bacteria quite apart from its effect in reducing numbers of bacteria.

This work on the interaction of the various groups of the soil organisms is being continued.

The work on nitrification described in the last Report is being continued.

EFFLUENT FROM SUGAR BEET FACTORIES

The study of the purification of effluents from sugar beet factories has been continued, and useful information has been obtained in regard to the possibility of inoculating filters with particular strains of bacteria.

SOIL BACTERIA

Bacterial Numbers in Field Soils

An essential part of the work of the Bacteriological Department is to form estimates of the numbers of bacteria in the soil. The plating method was used at Rothamsted for many years, and it

served the useful purpose of showing which factors increased and which decreased the numbers of bacteria in the soil, though it failed to record many of the groups, so that the results were always low.

A great improvement in the method of counting was made in 1928 by H. G. Thornton and P. H. H. Gray ; direct counts are made from stained films, and the difficult problem of estimating the minute amount of soil involved is overcome by mixing with a weighed quantity of the soil a known volume of a suspension of indigo particles the thickness of which has been determined with a haemocytometer. Bacteria and indigo particles are both counted in the stained films from this mixture, and, from the ratio of bacteria to indigo particles, a simple calculation gives the numbers of bacteria per gram of soil.

The method is not only much more rapid than the older one, but much more complete. The plating method usually gives numbers of the order 10 to 30 millions per gram of soil from our plots ; the new method gives numbers varying from about 1,500 million to 4,000 million per gram of soil. On the Hoosfield barley plots, for example, the numbers varied from 1800 millions per gram in the soil of Plot 1—0 (unmanured since 1856) to 3,600 millions on Plot 4AA (complete artificial fertilisers, including nitrate of soda every year since 1856). Further, the numbers in the different plots varied in much the same way as the yields, so that bacterial counts give some indication of the order of productiveness.

Bacteriological Methods of Assessing Soil Fertility

In recent years several bacteriological methods have been devised for assessing either the general fertility of the soil or else some special deficiency such as lack of lime or of phosphate. One of the simplest and most elegant is that of Winogradsky and J. Ziemiecka, and fortunately we were able to arrange with the authorities of the Pulawy Agricultural Institute, Poland, for Mme. Ziemiecka to work for some months in our laboratories applying the "plaques moulées" method to the soils of the classical plots. The results gave correct indications as to the presence or absence of adequate phosphate and lime supplies on the plots receiving no nitrogenous manure or only the normal dressings, but not on plots to which heavy dressings of nitrogenous manure were given. Further examination showed, however, that *Azotobacter* was either absent from these soils, or occurred in only small quantities ; when a culture of it was added as part of the test the results came out entirely correctly.

Counts of nitrifying organisms were made from some of the plots, and these showed some relationship with soil fertility.

During the course of her experiments Madame Ziemiecka isolated an organism of considerable interest, whose cells possessed the power of absorbing certain indicators such as Brom Thymol Blue. She also obtained a *Myxobacterium* which attacks cellulose, the first found in our soils.

THE NUMBERS OF FUNGI IN THE ROTHAMSTED SOILS

The quantitative methods worked out in the Mycological Department have been used by Jagjiwan Singh for estimating the numbers of fungi and actinomycetes in the Rothamsted soil. The types of fungi were much the same in the differently manured plots, but the numbers both of types and of individuals were always higher on the