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## Report for 1923-1924 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



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### Soil Micro-organisms

#### Rothamsted Research

Rothamsted Research (1925) *Soil Micro-organisms* ; Report For 1923-1924 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 31 - 32 - DOI: <https://doi.org/10.23637/ERADOC-1-116>

### THE MICRO-ORGANISMS OF THE SOIL.

Reference has been made in previous Reports to the important part played by the soil micro-organisms in determining the productiveness of the soil. These organisms break down the organic matter in the soil, the plant residues, farmyard manure and other organic manures, converting them into useful plant foods. They effect at least three kinds of action which are directly beneficial to the plant :—

1. The production of nitrates.
2. The decomposition of plant material producing structureless compounds having valuable colloidal properties.
3. The decomposition of intermediate products which would be toxic to plants.

The most striking result brought out by recent observations has been the fluctuation of the micro-organisms in natural field conditions. There are two-hourly fluctuations, recognised at present only in the case of bacteria, which have been measured in the Bacteriological Department. Superimposed upon these are daily fluctuations which are known to affect not only bacteria but protozoa also, the level of numbers for any species at 9 a.m. varying from day to day. Further, there are seasonal fluctuations; a great rise in spring, a fall in summer, a rise in autumn, and a fall in winter; bacteria, protozoa and apparently also algae and fungi being affected. It is not known whether there are annual fluctuations, though this would appear not improbable. The phenomena are not confined to soil micro-organisms; similar fluctuations are recorded for plankton and pond algae, though the data are not so complete.

The cause of the daily and probably of the hourly fluctuations of bacteria is fluctuation of the number of the amœbæ which feed upon them. Why the amœbæ should fluctuate was for long a mystery; Mr. Cutler and Miss Crump have thrown some light upon it by showing that rate of reproduction of amœbæ depends upon the number of bacteria present; when the bacteria fall below a certain level no division of the amœbæ occurs; it begins only when they rise above this.

The spring and autumn increases in number, however, affect bacteria and protozoa alike, so that some other cause is apparently operating.

All this work has been possible through the elaboration by Mr. Cutler of methods of counting protozoa in the soil, and the development by Mr. Thornton of a plating medium in which bacterial colonies would develop uniformly and without the spreading which in the older technique suppressed some of the slow growing forms. The medium has the further advantage of being prepared from pure substances so that it can be reproduced with precision whenever desired, and it has thus been possible to apply a statistical formula whereby the degree of accuracy of the plate counts can be estimated.

The quantitative measurements give a much clearer picture than was hitherto possible of the character of the soil population. The average numbers obtained in the high activity period of spring and the low activity period of the winter are as follows :—

			Numbers per gram of soil.	Approx. weight. lbs. per acre.
Bacteria	High Activity	...	45,000,000	50
	Low	„	22,500,000	25
Amoebae	High Activity	...	280,000	320
	Low	„	150,000	170
Flagellates	High Activity	...	770,000	190
	Low	„	350,000	85
Ciliates	High Activity	...	1,000	—
	Low	„	100	—

The weight (also the volume) of the protozoa in the soil considerably exceeds that of the bacteria in spite of the high numbers of the latter.

It is more difficult to ascertain whether the production of plant food fluctuates in the same way as the numbers of organisms. There are undoubted fluctuations, but more data are required before the proof becomes as rigid as it is for bacteria.

There is definite evidence that crops obtain only part of the possible food supply, much of the rest being taken by soil organisms and thus rendered unavailable. One cannot as yet say which are the worst offenders in this respect; at present suspicion attaches to the algae, and the laborious task of clearing up the problem is being carried out by Dr. Bristol Roach.

#### CONTROL OF THE SOIL ORGANISMS.

The knowledge of the soil organisms gained in our laboratories is allowing of a steadily increasing degree of control. There are at present four directions in which large scale tests are carried out.

1. Inoculation of lucerne by the appropriate micro-organisms.
2. Conversion of straw into a useful manure by the cellulose decomposing organisms.
3. Control of the plant food production process by partial sterilisation methods.
4. Control of plant disease organisms by similar methods.

Of these, inoculation has already been discussed on p.

*Artificial Farmyard Manure.*—The production of manure direct from straw is now being carried out on the large scale. In the past season no less than 3,000 tons of straw and like material were treated in Britain alone in addition to much larger quantities treated abroad.

The method of making artificial farmyard manure is based on the facts that the necessary organisms are already present and need only suitable conditions to call forth their