ROTHAMSTED RESEARCH

Rothamsted Report for 1947

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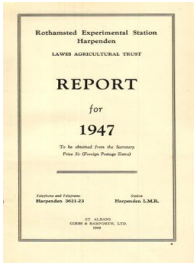

Soil Microbiology Department

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DEPARTMENT OF SOIL MICROBIOLOGY

By H. G. THORNTON

The following main lines of research were carried out during the year:—

A. WORK DEALING WITH THE SOIL MICROPOPULATION

(1) *The effect of soil micro-organisms on soil structure*

Rapid improvement in the crumb structure of soil can be brought about by incorporating suitable organic matter containing readily decomposable substances. This effect is produced scarcely at all by relatively resistant materials such as well rotted farmyard manure or compost. Mr. R. J. Swaby has isolated a variety of micro-organisms from soil to which readily decomposable organic materials had been added and has tested the effect on soil crumb structure of these organisms in pure culture and in mixtures of pure cultures. The greatest as well as the most stable improvement in soil structure was produced by soil fungal mycelium. Actinomycete mycelium produced less stable aggregates, while a very small and temporary effect was produced by cultures of bacteria that produce gums. Mixed cultures containing fungi were usually more effective than mixtures of actinomycetes, yeasts or bacteria, but micro-organisms in some of the mixtures tested were found to antagonise each other with reduced effect on structure. Soil fungi also improved the structure better than did a soil suspension containing a great variety of micro-organisms. The soil crumbs produced by micro-organisms are short-lived, even those produced by fungi breaking down if bacteria or other organisms capable of attacking fungal cell walls are also present.

The more permanent soil crumbs found in some soils such as chernozems, rendzinas, krasnozems and terra rossas, cannot be fully explained as direct effects of micro-organisms. The more resistant humus seems to play a part here and an attempt is being made to determine which of the humate fractions are mainly responsible.

(2) *Nitrifying bacteria*

Dr. Jane Meiklejohn in a study of the bacteriology of ammonia and nitrite oxidation has devised an improved culture medium for use in nitrification studies and has investigated the effect of trace elements on the nitrifying activities of crude liquid cultures. This work, carried out with the co-operation of Dr. H. Lees of the Biochemistry Department, showed that iron markedly stimulated the production of nitrite from ammonium salts. A mixture of 10 trace elements lacking iron, copper and zinc was found to depress nitrite formation; this depression was prevented by the further addition of iron or copper but not by zinc. A proper balance of minor elements hence appears important to the nitrification process.

(3) *Micro-organisms attacking resinous substances in soil*

Mr. P. C. T. Jones concluded his researches on microbial decomposition of "Vinsol" and "Gum rosin" in compacted soil,

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work undertaken on behalf of the Road Research Board, by investigating the stabilising action of various antiseptics added with the resins to the soil.

(4) *Soil actinomycetes*

Mr. F. A. Skinner commenced work here in August and is investigating the actinomycete flora of some Broadbalk plots comparing the flora of the wheat root surface with that of the main soil mass. This work is in its early stages.

(5) *Mycorrhizal associations*

Dr. Janet Mollison, who also commenced work here in August, has continued her investigation of mycorrhizal associations, particularly in clover and wheat roots. Her earlier work established that red and white clover plants growing in the field are always infected with a Phycomycete fungus that forms typical root associations of the "endomycorrhizal" type. A similar fungus has also been found in wheat roots and a survey is at present being undertaken of the relative abundance of mycorrhizal infections on wheat roots from variously manured plots of Broadbalk in samples taken at regular intervals. This is being carried out in conjunction with estimates of the content of fungal mycelium in these soils.

Experiments to test the comparative growth of clover with and without the Phycomycete and to study the conditions determining infection and emergence from the root are under way.

(6) *Myxobacteria*

The numbers of this group that attack true bacteria by means of antibiotic secretions are of special interest in connection with the competition between sections of the soil population. Knowledge as to their distribution in soils was wholly lacking until Dr. B. N. Singh made a survey of their distribution in Rothamsted plots and in soil samples from a wide area in Britain. He is now extending this survey to soils obtained from other parts of the world.

(7) *Protozoa.* (a) *Giant rhizopods*

Dr. B. N. Singh has continued the study of the life history and feeding habits of the giant Rhizopod, *Leptomyxa* Goodey, which he has found to be abundant in arable soil. Its development in soil under laboratory conditions is unaffected by reaction over a range fram pH 4·2 to 8·7 nor is its distribution in field soils related to their reaction. The organism is specific in its bacterial food requirements and was found to eat rather less than half of the 92 species of bacteria supplied to it in a test. It differs markedly in its preference for particular bacterial species both from true soil amoebae and from the amoebula stage of Acrasieae, but it resembles these in its dislike for bacteria that produce pigments other than yellow or orange and in its indifference to the gramstaining reaction of the bacteria.

A single individual Leptomyxa contains a large number of nuclei which undergo simultaneous division by an unusual form of mitosis in which the nuclear membrane and the nucleolus persist until telophase. The organism produces multinuclear cysts in a manner unique amongst protozoa but resembling the sclerotium formation in Myxomycetes. This formation of cysts is dependent

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both on the cultural conditions and the species of bacteria supplied as food. Of 65 strains of bacteria edible to it only 20 led to the production of cysts in any considerable numbers.

(7) *Protozoa.* (b) *Effect of bacterial food on the life cycle of soil amoebae*

The part taken by active amoebae in consuming bacteria in the soil makes it important to understand the effect of the type of bacterial food on the growth of amoebae. Dr. B. N. Singh has found in previous work that certain species of bacteria are readily eaten while others are inedible to soil amoebae. Miss L. M. Crump has found that such amoebae can be trained to feed and multiply normally on a species of bacterium that was at first almost inedible to them. When fed on a pure bacterial culture whether originally edible or not the amoebae tend to lose the ability to form cysts.

(B) Investigation concerning the Nodule Bacteria of Clover

(1) *Stability of bacterial strains as regards effectivity*

The tendency for strains of the nocule bacteria to change their effectivity towards the clover plant in certain soils (see previous reports) is of great importance affecting the chances of improving clover growth by inoculation. Dr. J. Kleczkowska is investigating the problem of strain stability along two lines.

First, the tendency to produce ineffective mutants in soil is being investigated by using a strain known to be liable to change and growing this in a variety of soils in the hope of discovering the soil conditions producing the change, and also by growing a number of bacterial strains in a soil known to produce changes in some strains, in the hope of discovering a genetically stable strain. This investigation is still in progress.

Secondly, the known tendency for bacteriophage to induce the appearance of mutant forms of the bacteria differing from the parent strain in effectivity is being studied. Three bacterial strains originally ineffective towards clover were subjected to the action of 'phage. With one of these strains the 'phage failed to produce mutants differing in effectivity from the parent strain. In a second case effective and intermediate mutant strains appeared and retained their new characters after isolation and purification by plating and plant passage.

In the third case effective and intermediate mutants were obtained but repeated plating from single colonies always produced a mixture of isolates differing in effectivity, about 60 per cent. of them being ineffective. This result indicates that strains differ greatly in their stability as regards their effect on clover.

(2) *The ability of bacterial strains to establish themselves in the field*

Success in the commercial "inoculation" of legume crops clearly depends first on the ability of the bacteria used as the inoculum to become established in the soil and produce an adequate number of nodules in the crop. Where inoculation is used to replace "wild" strains of nodule bacteria that are ineffective towards the crop, by an introduced effective strain, it is necessary to use for inoculation a bacterial strain able to establish itself in

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competition with the wild strains already present in the soil. Miss Margaret Thomas is investigating the ability of selected effective strains of bacteria to produce nodules on clover inoculated with them under field conditions. Trials have been run at half a dozen centres. These involve the isolation of bacteria from an adequate number of nodules from inoculated and untreated plots and serological identification to determine the percentage of nodules in the treated plots that were produced by the inoculum. This work is still in progress.

(3) *Genetics of clover in relation to nodule formation*

Further work by Dr. P. S. Nutman in the inheritance of resistance to nodule formation suggests that the production of the cytoplasmic factor considered to be responsible for the maternal component in the inheritance is itself determined by the recessive resistant factor *r*. More than one simple resistant factor has been identified in material of different origin.

Grafting experiments with resistant and susceptible plants have shown that the resistance of the root system is independent of the genetic constitution of the scion.

Studies in the inheritance of the effectivity response have been continued.

(4) *The physiology of nodule production*

An examination has been made by Dr. P. S. Nutman of the influence of delayed inoculation on nodule formation. With effective strains moderate delay leads to an enhanced rate of nodulation but further delay to a reduced rate, but following delayed inoculation with ineffective strains no increase in rate is evident. This result is consistent with the theory that the early formation of effective nodules results in the secretion into the neighbouring tissues of a substance inhibitory to the formation of other nodules or of lateral roots nearby, but that ineffective nodules degenerate before this substance can be produced. Further experiments to test this hypothesis are in progress.

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