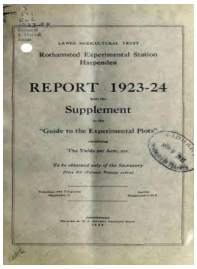
# Report for 1923-1924 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.

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## The Leguminous Crops: Inoculation

### Rothamsted Research

Rothamsted Research (1925) *The Leguminous Crops: Inoculation ;* Report For 1923-1924 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 24 - 26 **- DOI: https://doi.org/10.23637/ERADOC-1-116**

in the spring before the roots. The fact that the corn harvest is earlier in this part of the country, so that green crops can be sown earlier, also helps. Outside of this region autumn sown green crops do not in general make enough growth by the spring to be useful for green manuring purposes; this has happened at Rothamsted for three successive seasons (1921-1924).

The problem therefore arises of finding a system of green manuring for roots which is applicable to the colder northern and eastern districts.

Undersowing of green crops in the corn, and possible new crops are being tried : and at certain centres the relative economic values of folding the green crops to sheep, and of turning them in for manure, are being ascertained.

## THE LEGUMINOUS CROPS.

Considerable attention has been devoted to the leguminous crops, owing to their great importance in the rotation and as stock foods. The effect of manures applied to the barley on the clover sown in is shown on pp. 114, 115. Sulphate of ammonia had no bad effect on the clover although it increased the yield of barley. We have met cases where the application of sulphate of ammonia to barley reduced the yield of the clover, but in our experience this happens only when the land badly needs lime, and it is attributable to the increased acidity which sulphate of ammonia is liable to produce on such soils. The phosphate apparently had no action while the potash exerted a distinct residual effect, giving an additional 6 cwts. of clover hay in 1924 and 12 cwts. in 1923. The results indicate that potash should be applied to the clover if the barley crop has been good, unless it has already been given to the barley.

### *Inoculation of leguminous crops, especially lucerne.*

Ever since 1890, when Hellriegel and Wilfarth discovered that leguminous plants live in association with micro-organisms inhabiting the nodules on their roots, efforts have been made to improve the growth of leguminous crops by adding the appropriate organisms to the soil. Some successes were obtained on the Continent, but the method failed in this country; the results at Rothamsted in 1906 and 1907 were not then considered sufficiently good to justify extension to farm practice.

There is no doubt, however, that for certain crops the principle is sound; the failure of inoculation in Britain must be attributed to the lack of compliance with the conditions necessary to success. During the past three years the whole subject has been re-examined in the Bacteriological Department.

The subject affords an admirable illustration of the way in which a practical problem of great importance remains unsolved, in spite of many empirical efforts, until the underlying principles have first been studied and a solid groundwork of definitely ascertained facts has been obtained.

The failure of inoculation in many cases has been traced to the circumstance that the organisms were already present in the soil, but some condition essential to the growth of the plant

*https://doi.org/10.23637/ERADOC-1-116* 

was not realised, and the deficiency could not be remedied by merely adding more of the organisms.

Further, it was shown that many of the cultures sent out to farmers died on the way, so that the material used for inoculation was useless. This difficulty has been overcome by devising means whereby the organisms could be transported alive. The need for fresh, active stocks of the organisms available for farmers at short notice has been met by devising a medium in which the organisms grow much more quickly than in the older media.

The organism cannot flourish in soils having too great a degree of acidity; a usual limit corresponds with the pH scale number 6.0.

A much more difficult problem is being attacked in the Bacteriological Department. The organisms were found to pass through a life cycle including motile stages in which they can travel to the plant, and non-motile stages in which they cannot. The non-motile stage can, however, be made to change into the motile stage by certain treatments, especially the application of phosphates; this is no doubt one reason for the remarkable effect of basic slag in increasing the growth of clover on certain soils. Messrs. Thornton and Gangulee have measured the time required for the organisms to assume the motile form in the soil, and the rate at which they then spread through it. On the basis of these various facts, Mr. Thornton has been able to devise a method of inoculating which ensures an earlier commencement of spread of the organisms in the soil, and therefore a better chance of infection of the roots, than in any method previously tried in this country.

The Research Committee of the Royal Agricultural Society has made a grant to Rothamsted which is allowing extensive trials to be carried out at some thirty centres scattered throughout England to test the value of the method for lucerne. It is too soon to speak definitely about the results, but already inoculation has proved of considerable value in new districts where the crop has not previously been grown, and it has in places doubled the growth in the first year as compared with the uninoculated plots, besides giving vigorous plants which promise to survive and come out in full strength in the summer. Meanwhile the purely scientific study of the organism and of its relation to the plant is being steadily pursued with the object of getting further information. Exceptions and difficulties will inevitably arise as soon as farmers adopt inoculation as a general practice, and the surest way of minimising the resulting losses and inconveniences is to obtain the fullest possible knowledge of the whole process.

Two investigations have been carried on which cannot fail to have important bearings on the practical problem. The first, which is still in hand, is concerned with the influence of straw on the formation of nodules. Attention was directed to this by the observation that farmyard manure is more effective in increasing the growth of clover than any dressings of artificial manures

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yet tried. In pot experiments unrotted straw greatly increased the numbers of nodules formed on each plant; there was, however, no increase of yield till phosphates were added. A dressing of straw and phosphate has been found in field tests to be an effective fertiliser for beans and affords a method of increasing the organic matter of the soil which might find useful application in practice.

The second investigation brings out the fact that the plant is just as important as the organism in the partnership. It arose as a result of Miss Warington's important discovery that many leguminous plants fail to grow unless supplied with traces of boron. Dr. Brenchley and Mr. Thornton, taking the broad bean as their example, showed boron to be essential to the proper functioning of nodules on its roots. In the normal course, conducting vessels grow out from the vascular system of the plant root and enter the nodule. Along these vessels food materials are brought from the plant to the bacteria, and the products of their activity are carried back to the plant. The vessels thus act as conduit pipes, connecting the organisms with the plant and making the partnership effective. In the absence of boron these vessels do not form or are very weakly developed. The organisms, losing their normal source of food, become parasitic and destroy the plant protoplasm, being then harmful instead of useful to the plant. The work thus shows that the organism is a potential parasite; only by the nice adjustment occurring in the healthy plant can the beneficial partnership be maintained.

In most soils there is apparently sufficient boron to allow of full development. But instances are on record in Japan, and possibly elsewhere, where peas, which do not need boron, will grow while other leguminous plants which need it will not. In these soils there might be a boron deficiency. The more important result emerges that the successful growth of a leguminous crop depends on three conditions: presence of the proper organisms and soil conditions necessary for their growth; the proper nutrition of the plant; and development of the conducting system linking the organisms in the nodule with the circulating system of the plant.

*Liming.*

The effect of lime on sour arable land and on certain kinds of grass land is well known and farmers are frequently advised to use more of this substance. But directly they begin to follow the advice they are faced with the difficulty that analysts cannot as a rule inform them just how much lime per acre they should apply, and a round figure of one or two tons per acre is often suggested. The recommendation suffers from the defect that no farmer can afford to supply two tons per acre if one ton is sufficient, apart from the consideration that too large a dressing may injure the crop or the soil.

Various empirical methods have been devised from time to time to give some idea of the quantities needed, but the different tests give different results, and in absence of definite knowledge

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