



# INOCULATION OF CLOVER SEED

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You may wonder what business a soil scientist has to be writing about inoculation problems. Firstly, the nodule bacteria are soil micro-organisms and their numbers and activity depend to some extent on soil properties. Secondly, it is no good correcting deficiencies of lime, phosphate, sulphate, molybdate, potash and the like when sowing clover, unless the clovers become nodulated and fix their own nitrogen from the air; and thirdly by paying attention to inoculation it is sometimes possible to establish clover on quite acid soils with a minimum amount of lime, because some bacteria are more sensitive to acidity than their host plants.

Most farmers would never dream of sowing lucerne without inoculating the seed with the special bacteria available, even upon resowing a ploughed lucerne paddock, when there is every chance of the soil containing the right kind of bacteria. Indeed the soil from established lucerne paddocks was once widely used to inoculate seed for new sowings. Presumably there have been so many failures or partial lucerne failures due to faulty inoculation that it is better to be safe than sorry.

Farmers rarely inoculate peas, beans and clover. As far as annual legumes are concerned they may grow quite well without nodulation if they can pick up enough mineral nitrogen from decomposing organic matter, for instance it is doubtful if it matters at all whether peas get inoculated or not, if they are sown in ploughed up pasture. It is a different matter where clovers are growing with grasses. Grasses can compete very successfully with

clovers for mineral nitrogen, and unless the clovers become nodulated and fix their own nitrogen, they do not flourish. However, farmers so seldom inoculate their clover seed that partial or complete failures to establish clovers must be very rare, otherwise they would be more aware of the problem. The clovers must be picking up bacteria from somewhere.

Where do the bacteria come from? Bacteria are often present on the seed, and except on some very poor soils there will also be some in the soil. Therefore even if the seed is not inoculated specially, there is a good chance of plants becoming nodulated sooner or later. The chances of this happening must be high because there were no clovers in New Zealand before Europeans came and in the early days there was no special effort made to inoculate the seed because the vital function of nodule bacteria was undiscovered until the late 19th Century.

It is now known that there are many different strains of bacteria some of which are considerably more efficient at fixing nitrogen than others. This is important because once a plant has become inoculated with an inefficient strain it is unlikely to become infected with more efficient bacteria. Consequently some of the clovers in our pastures may be producing much less than they might.

Micro-biologists have selected very efficient strains of bacteria suitable for various legumes and there should be more experiments on improved country comparing inoculated and uninoculated seed. It costs very little to inoculate clovers with highly efficient strains of bac-

teria, and there is no excuse for us not having very specific evidence as to its merits. In fact, the author knows of no results of properly designed field experiments in this country, comparing inoculated and uninoculated clover seed on land that has been developed for a long time.

The story may be different on soils still undergoing development from tussock grasslands or scrub and fern. It is known that inoculation encourages the establishment and growth of clovers on some of these soils, but it is not universally necessary because there are many fine improved areas, recently developed, growing vigorous clovers which were not inoculated at sowing. More research is needed to define the areas where clover should be inoculated.

#### Some of the factors involved:

There is little doubt that the pH or degree of acidity of the soil influences nodulation. It is interesting to follow developments in this field since A. J. Anderson showed in Australia that subterranean clover could be made to grow quite well on some acid soils by using a few ounces of sodium molybdate per acre instead of a ton or more of lime. This was of vital importance in a country the size of Australia where long road-hauls make lime costly. Molybdenum has also made its impact in New Zealand. To cut a long story short it was soon found that when molybdenum was applied to some acid soils, nodulation was poor where no lime at all was applied; 1 or 2cwt of lime drilled with the seed along with molybdenum was enough to improve nodulation in some soils. The final development was to show that if the seed were inoculated and a coating of finely ground limestone stuck on the seed with glue, then clover establishment, nodulation and growth were greatly improved.

The significance of this early Australian work was that liming soils could both correct molybdenum deficiency and improve clover nodulation and that on some acid soils the use of molybdenum and inoculated lime-coated seed could reduce the cost of pasture establishment by cutting out the cost of liming. There may well be good reasons for lim-

ing but this question is not under discussion here. Indeed there are many soils where lime may be most important.

#### Experiments:

Mr W. R. Lobb, of the Department of Agriculture, obtained benefit from inoculation and seed-coating in Canterbury and the problem was examined subsequently at Lincoln in pot experiments in 1958. The results for sub. clover grown on a High Country soil with a very low pH of 4.9 are shown in Table 1.

TABLE 1.

Subterranean Clover. Dry matter, grams per six pots.

Treatments	Not Inoculated		Inoculated	
	Not Pelleted	Pelleted	Not Pelleted	Inoculated and Pelleted
No lime	1.5	3.2	6.8	
30cwt per acre	4.6	9.1	7.1	
60cwt per acre	5.1	7.8	5.2	

The first column of figures down shows the effect of liming on yields of clover where seed had not been inoculated or pelleted with lime. This is really equivalent to traditional farm practice. The first row of figures across demonstrates the effects of inoculation and pelleting, and the yield of 6.8 grams from inoculated, pelleted seed in the absence of lime compares favourably with the yield of 5.1 grams from 3 tons of lime applied where the seed was not inoculated or pelleted. This was just what A. J. Anderson found in Australia. It is still not known why pelleting the inoculated seed coupled with liming gave lower yields than when the seed was only inoculated. White clover and lucerne both gave somewhat similar results.

In August, 1962, a field trial similar in design to the pot trial was put down on an acid soil (pH 4.9) at the top of Lake Ohau. The poor tussock grassland was oversown with a mixture of red, white and alsike clovers, and because of very severe deficiencies of sulphur and phosphorus, 4cwt per acre super was applied all over. Table 2 shows the yields of clover harvested in April, 1963.

TABLE 2.

Clover Yields. Dry matter, pounds per acre.

Treatments	Not Inoculated Not Pelleted	Inoculated Not Pelleted	Inoculated and Pelleted
No lime	173	442	459
10cwt per acre	229	895	739
40cwt per acre	316	1105	677

These results follow a pattern very similar to that of the pot trial. Liming at 40cwt per acre without inoculation and pelleting was poorer than inoculation and pelleting in the absence of lime. Inoculation without pelleting had big effects particularly where the soil had been limed, and interestingly enough, pelleting inoculated seed gave poorer results than no pelleting, where the soil had been limed, in exactly the same way as in the pot trial.

It is quite obvious from these results that inoculation of clover in some of the very acid high country soils may make all the difference between success and failure. Anything which ensures rapid nodulation of the clover, and therefore more vigorous growth and a more extensive root system will mean the survival of the plant during the almost inevitable dry summer period. The more clover plants that survive, the more rapidly will production increase. Apparently some liming of these very acid soils would be beneficial, but if this is not done then pelleting of the inoculated seed would be desirable. Pelleting would also be very desirable, if indeed it is not essential, where farmers mix fertilizer with inoculated seed before sowing, as direct contact between fertilizer and inoculant may kill the bacteria. Pelleting is also essential if the seed is to be inoculated and stored for some time before use.

We are searching for the reason why pelleting depresses growth on limed soils in further experiments. Two of the possible factors among others being examined are the kind of material used for sticking the coat on the seed, and the kind of coat being put on the seed. In the

experiments mentioned above we used glue to make lime pellets. Now Hastings and Drake of the Plant Diseases Division and Proctor of Plant Chemistry, have shown that some constituent or additive in the glue may harm bacteria, particularly if the seed is stored. Methyl cellulose on the other hand is a harmless glue and is therefore much safer. However, we have noticed no difference between glue (specially prepared for coating) and methyl cellulose when the seed was sown immediately after preparation. If the glue were responsible for damaging the bacteria then it might account for the lower yields from pelleting where the soil was limed, but it would not explain why pelleting in the absence of lime was not harmful. Messrs Hastings and Drake have also compared different kinds of material for coating. It appears that a mixture of ground rock phosphate (Gafsa) and dolomite is better than finely ground limestone, particularly when inoculated seed is stored. Consequently we are experimenting to see if this type of coat overcomes the depression from pelleting, or whether, where the soil is not limed, a different kind of coat will give better results than the lime coat.

The object of this kind of research is to find ways of improving herbage production at the lowest cost, and it is quite obvious that there are many problems which still have to be solved.

#### Conclusion:

It may be helpful to summarise any practical conclusions that can be drawn from the present evidence on inoculation and pelleting of clover seeds.

#### Improved Soils:

There is not enough evidence to recommend clover seed inoculation when sowing a new pasture on improved land that has been growing good pastures.

However more experimental work is needed. It costs so little to inoculate clover seed that one would like to see some farmers experimenting with it. However we would not recommend pelleting on limed soils in our present state of knowledge, except for protecting the inoculant from direct contact with fertilizer. The use of lime-reverted

super might do away with the need for pelleting the inoculated seed. Although this bulletin is about clovers, lucerne must be mentioned. There is enough evidence to suggest that unless soils have been limed so that the pH is between 6 and 6.5 inoculated lucerne is very likely to benefit from pelleting; the lucerne bacteria and the actual process of nodulation of lucerne seem to be more sensitive to acidity than in the case of clovers.

#### **Tussock Country or any other Land Undergoing Initial Improvement:**

There is enough evidence now to suggest that inoculation of clover seed may greatly assist establishment on very acid soils. It would be a wise and cheap precaution to introduce highly effective nitrogen-fixing bacteria when first establishing clovers on this country. The need for inoculation may be less if time of sowing and climatic conditions are satisfactory; for instance if the seed is sown early enough, say in July or August, there may be time for bacteria from natural sources to produce nodulation before dry condi-

tions set in. I would still prefer to inoculate the seed and minimise the risks. The merits of pelleting are more difficult to assess in the present state of knowledge. If a farmer inoculates his own seed just before sowing, uses lime-reverted super and gives a light liming (say 10cwt per acre) on very acid soils, there may be little advantage from pelleting. If he has not limed, if he wants to sow his seed with straight super or sulphurised super with or without molybdenum, or if he wants to store inoculated seed for some days before sowing, then pelleting would probably be beneficial. Current research on these problems will lead sooner or later to the cheapest possible methods of clover establishment—the first phase of pasture improvement.

Finally a well-nodulated clover plant will only thrive if all other factors, particularly nutritional, are corrected. It is no good fitting false teeth in a toothless tiger and then starving it of meat; a nodulated clover plant will only fix nitrogen if we correct all deficiencies of phosphate, sulphate, molybdate, potash or any other elements.

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