Nodulation of legumes on new light land. 4. Rhizobial strains for pasture establishment

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NODULATION OF LEGUMES ON NEW LIGHT LAND

4.—Rhizobial strains for pasture establishment

By OLGA M. GOSS and W. A. SHIPTON, Plant Pathology Branch

LEGUMES are the basis of improved pastures in Western Australia. Successful establishment of these legumes depends on the presence in the soil of suitable bacteria which will invade the roots and develop nodules in which nitrogen fixation is carried out. The nitrogen compounds produced are utilised by the plants, making them independent of soil nitrogen. At the end of the season, the decomposition of the plant residues improves soil fertility.

The value of seed inoculation with rhizobial strains of proved efficiency cannot be over-emphasised. This is especially true for virgin soils or areas where the particular legume has not previously been grown successfully.

Even on soils where rhizobial bacteria capable of infecting the roots and developing nodules are present, these are not necessarily the most effective strains and therefore it is a wise insurance to inoculate pasture legume seeds with the recommended culture before planting.

Need for Inoculation of the Various Legume Types

Lucerne and other Medics

Bacteria suitable for this group are rarely, if ever, found naturally in the soil in Western Australia. Hence seed inoculation is essential for successful establishment.

Clovers

In most new areas seed inoculation is necessary, but there is an occasional exception, for example the Esperance region where good establishment of subterranean clover can be obtained without inoculation. However, even in this area definite benefit can sometimes be demonstrated by the use of specially selected strains.

Field Peas

Results with this legume are variable, but if there is any doubt about the presence of suitable rhizobia in the soil, inoculation is warranted.

Lupins and Serradella

Indigenous rhizobia capable of infecting lupins are fairly widespread, but of the commonly grown varieties of lupin, only the Western Australian blue is nodulated satisfactorily (Lange, 1961). Inoculation is necessary for the establishment of serradella on new land.

Strains of Rhizobia

The occurrence of nodules on the roots of legumes does not guarantee satisfactory growth. There are many different strains of rhizobia, and these differ in their ability to invade legume roots and in their effectiveness once infection has taken place. Under most field conditions nodules that are fixing nitrogen efficiently are pink to red in colour when cut, whereas ineffective or non-functioning nodules are greenish in colour.
The effectiveness of strains frequently varies with the plant species. This is particularly evident with the clover strains. Some strains are virtually useless on, for example, red clover, but very good on subterranean clover, other strains are almost equally effective on most clover species.

Differences in the effectiveness of rhizobial strains are evident even within the subterranean clover group. For example the Woogenellup strain nodulated very poorly with the rhizobial strains used in commercial cultures before 1963, although these were quite satisfactory on other varieties, such as Geraldton.

To obtain the best pasture stand it is necessary to inoculate with a highly efficient strain of Rhizobium. Research workers are constantly searching for and checking new strains to find more effective ones. Strains are selected mainly on their ability to ensure good pasture yields, but also on their ability to nodulate freely as many legume species as possible.

**CLOVER STRAIN EXPERIMENT AT BADGINGARRA**

The differences in clover establishment attributable to rhizobial strain differences are apparent in the strain experiment conducted at the Badgingarra Research Station on new light land in 1964. Three rhizobial strains, namely: TA1, UNZ29 and WA67, and mixtures of these three strains were tested on four types of clover (Woogenellup and Geraldton varieties of subterranean clover, rose clover (*Trifolium hirtum*) and *trifolium cherleri*).

**Nodulation and Yield**

Nodulation and yield assessments gave the following results:

**Woogenellup Subterranean Clover**

Strain WA67 and this strain in conjunction with any other of the three under

![Diagrammatic representation of the nodulation differences obtained when various clovers were inoculated with different strains of rhizobia.](image-url)

Fig. 1.—Diagrammatic representation of the nodulation differences obtained when various clovers were inoculated with different strains of rhizobia.

- **A = UNINOC.**
- **B = UNZ29**
- **C = TA1**
- **D = WA67**
- **E = WA67 + UNZ29**
- **F = TA1 + UNZ29**
- **G = TA1 + WA67**

*Nodulation value assessed by the method given by Goss and Shipton (1965)*

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test were significantly better than the other treatments (5 per cent. level). TA1 was not significantly better than the control (uninoculated), but all other treatments were better (0.1 per cent. level).

**Geraldton Subterranean Clover**

In this case there was no significant difference between strains, but all were better than no inoculation (0.1 per cent. level).

**Rose Clover (Trifolium hirtum)**

Again all strains were significantly better than the controls (0.1 per cent. level). In this experiment there was little difference between strains, probably due to rain wash.

**Trifolium cherleri**

WA67 alone was the best treatment, but this strain in association with any other was better (1 per cent. level) than UNZ29, TA1 or UNZ29 + TA1. However, all strains were significantly better (0.1 per cent. level) than the control (uninoculated).

These differences in nodulation and yield are shown diagramatically in the accompanying histograms.

The conclusions from these results may be summarised as follows:

- Strain WA67 (which was isolated in Western Australia for Wooroneup subterranean clover) or this strain in combination with another strain is among the best on all the clovers under test.
- Strain TA1 is very poor on Wooroneup subterranean clover and *T. cherleri*.
- Strain TA1 + UNZ29 (the commercial culture) is poor on Wooroneup and *T. cherleri* and, to a lesser extent, on Kondinin rose clover. A special commercial culture is now available for these clovers.
- The Geraldton variety of subterranean clover is less selective and nodulates successfully with all strains under test.

**Survival in Soil**

Strains of rhizobia also differ in their ability to colonise the soil, and some do not persist from one season to the next. These aspects are important for successful nodulation in the second and subsequent years. Observation in 1965 of the
strain experiment just discussed, has shown that under the conditions of this experiment, strain TA1, which is included in the commercial peat culture for clovers, has a poorer survival ability in the soil than the other strains tested.

Even with Geraldton subterranean clover, where differences between strains were not apparent in the first year of establishment, strains TA1 and, to a lesser extent, UNZ29, are inferior to WA67. Similar trends are evident with all the other clovers, indicating that TA1 does not survive satisfactorily in the soil whereas WA67 would appear to be satisfactory in all cases. (See table).

Discussion

The failure of the bacteria to survive in and colonize the soil results in "second year mortality."

Second year mortality of clover is an important problem in Western Australia, and has been particularly serious this season in the northern agricultural region. The problem may persist to a decreasing extent into the third and fourth years and even longer. Marshall et al (1963) estimated that about 80 per cent. of the 12 million acres of land still likely to be developed in the agricultural regions would be potential problem areas. Moreover, second year mortality can be experienced on land that has been cleared for many years. Hence a strain of rhizobium which will satisfactorily colonize the soil is of vital importance. The soils concerned are mainly the light grey sands, either deep or with some gravel close to the surface. The problem varies considerably from locality to locality but it has been noted with a large range of legumes, and in severe instances may cause the death of more than 80 per cent. of the seedlings.

Research is in progress to select strains of rhizobia which possess an increased ability to colonize and survive in these sandy soils where second year mortality is serious.

On some of the lighter soil types, some farmers have reported difficulties in establishing satisfactory stands of subterranean clover after cropping, even though clover pastures had been established on these soils for several years before cropping. The plants either nodulate poorly or carry the nodules well down on the root system. This problem is caused by the failure of the bacteria to survive in the surface layers of the soil. It can be overcome by inoculating the seed, thus ensuring early and adequate nodulation and sustained pasture production.

RECOMMENDATIONS

All legume seeds sown on new land or on areas where the legume has not previously been grown successfully should be inoculated and pelleted. Subterranean

<table>
<thead>
<tr>
<th>Legume</th>
<th>Strains of rhizobia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WA67 + UNZ29</td>
</tr>
<tr>
<td>Woogenellup sub. clover</td>
<td>98</td>
</tr>
<tr>
<td>Geraldton sub. clover</td>
<td>99</td>
</tr>
<tr>
<td>Kondinin rose clover</td>
<td>85</td>
</tr>
<tr>
<td>T. cherleri</td>
<td>90</td>
</tr>
</tbody>
</table>

Second year establishment

Second year establishment of various clover species which had been inoculated with different strains of rhizobia in the initial year. The percentage of plants showing mortality symptoms was estimated visually, and the results are expressed as a percentage of plants nodulating satisfactorily in the second year.
clover is a possible exception in some areas. If there is any doubt about the presence of adequate numbers of efficient bacteria, it is a wise insurance to inoculate.

In areas where farmers have not previously tried seed inoculation or where inoculation was tried some years ago with disappointing results, it is suggested that strips of inoculated seed be sown through the paddocks and any resultant differences noted. In many areas improved stands in the inoculated areas will be noted. This is largely due to the rigid control being maintained on the quality of the commercial cultures and the improved strains being used.

When old pasture areas are re-sown, it is wise to inoculate at least some of the seed being sown to check on the degree of improvement which might be gained from the use of the new and better strains now available.

ACKNOWLEDGMENTS

Grateful thanks are due to the Manager of the Badgingarra Research Station (Mr. R. Clausen) and his staff for assistance with soil preparation and planting of the experiments; to Mr. W. Pickering and Mr. R. Gibson for assistance with planting, nodulation assessments and harvesting; to Mr. M. Thornett for statistical analysis of the data.

REFERENCES


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