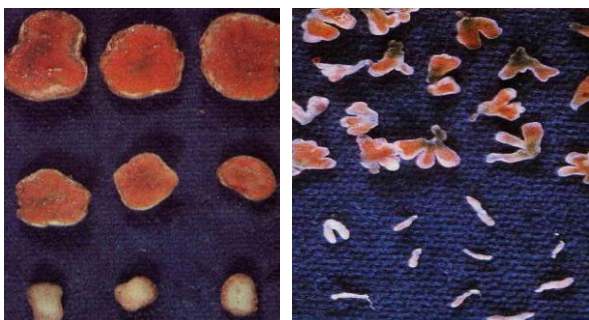


Where can inoculants be obtained?

Rhizobial inoculants for fodder legumes are produced and supplied by the Soil Microbiology Unit, NSSC, Simtokha. Inoculants for other legume species can also be produced on demand. *For further information, contact the National Soil Services Center, Simtokha.*

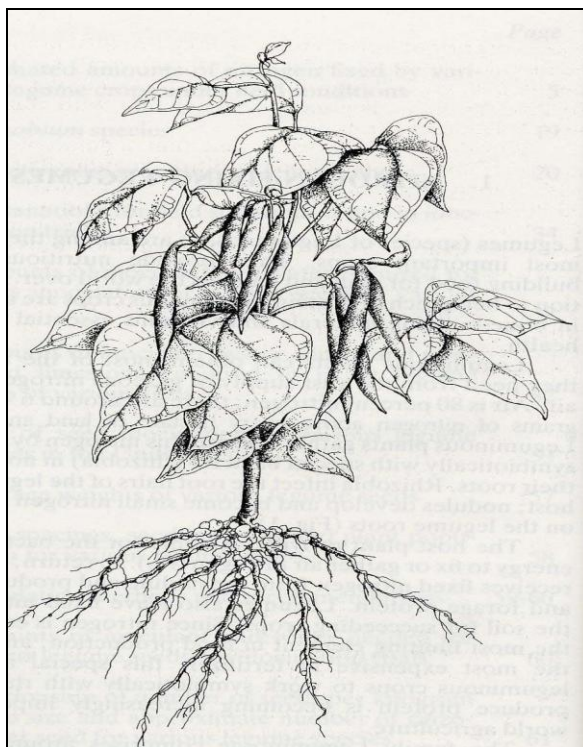


Soybean (*Glycine max*) White clover (*T.repens*)



Section of soybean nodules. Top: effective, Bottom: ineffective

Section of *Trifolium* spp. nodules. Top: effective, Bottom: ineffective



Ministry of Agriculture



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National Soil Services Centre



SPAL SFU SSU SMU SLMP



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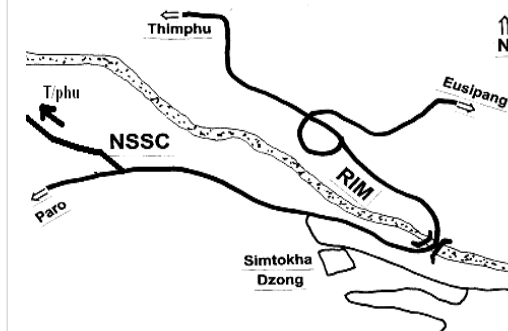
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BIOLOGICAL NITROGEN FIXATION

Leaflet No 8



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BIOLOGICAL NITROGEN FIXATION

One of the essential plant nutrients on which successful agriculture depends to a great extent, is nitrogen. It is the nutrient needed in the largest quantities and the most expensive in fertilizer. Nitrogen is provided to crops by:

- Chemical fertilizers
- Organic manures and
- Nitrogen fixing micro-organisms

Because soils are often low in N content, good plant growth often means supplementing soil nitrogen with fertilizer N that is too costly for many small farmers to buy.

Air is 80% nitrogen but plants cannot make use of atmospheric N_2 directly. Leguminous plants gather and use this nitrogen with the help of special bacteria (rhizobia) in nodules on their roots.

Rhizobia infect root hairs of leguminous host; nodules develop and become small nitrogen factories on the legume roots. The host plant provides a home for the bacteria and energy to fix or gather air nitrogen (N_2). In return, the plant receives fixed nitrogen from the nodule and produces food and forage protein. Legumes also leave fixed nitrogen in the soil for succeeding crops.

Management should always aim to conserve fixed nitrogen for use in crop production. One way to achieve this is through the use of

Rhizobium inoculants.

1. General information on rhizobial inoculants

When the soil does not naturally contain the nitrogen fixing *Rhizobium* for a legume that we want to grow, the necessary bacterial strain has to be added to that soil.

Nodule bacteria (*Rhizobium* spp.) are cultured in the laboratory and combined with a suitable carrier material, such as peat to make an inoculant.

2. What is inoculation?

The process of providing a legume with *rhizobium* by adding inoculants to seed or soil is called inoculation. Inoculation makes it possible for legume to form nodules that fix atmospheric nitrogen.

3. Which legumes have to be inoculated?

Rhizobia are host specific, i.e. the legume crop species must have the right *rhizobium* species or they will not be able to form nodules and fix nitrogen.

Inoculation is almost always needed when:

- The *rhizobium* is absent from the soil (no nodule formation on plant roots). This can occur:
 - When certain new leguminous crops are introduced to new areas or regions
 - When environmental conditions are

unfavorable for the species (soils with pH less than 5.5 or more than 7).

- *Rhizobium* are present in reduced numbers (a few large nodules but less than 10 per plant).
- Non-nitrogen fixing strains are present (nodules small and numerous usually distributed throughout the root system).

4. Assessing the presence of rhizobia in soil and their ability to fix atmospheric nitrogen

Presence of nodules on the legume roots indicates presence of native *rhizobia* in soil.

Effective nodules are generally large and clustered on the primary and upper lateral roots, deep reddish color inside but lose this color when senescent. Ineffective nodules are small, numerous usually distributed throughout the root system and white to pale green inside. They do not change color as they age.

The effectiveness of *rhizobia* in fixing atmospheric nitrogen can be determined by slicing the nodules of the legume host during early flowering period and noting the nodule color.