ILLUSTRATED CONCEPTS IN AGRICULTURAL BIOTECHNOLOGY

A series from the NifTAL Project-MIRCEN, Department of Agronomy and Soil Science*
College of Tropical Agriculture and Human Resources
University of Hawaii

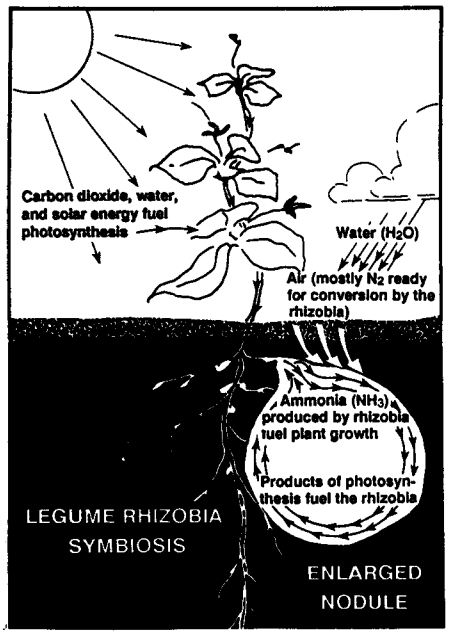
Biological Nitrogen Fixation (BNF): Commonly asked Questions and Answers

About nitrogen

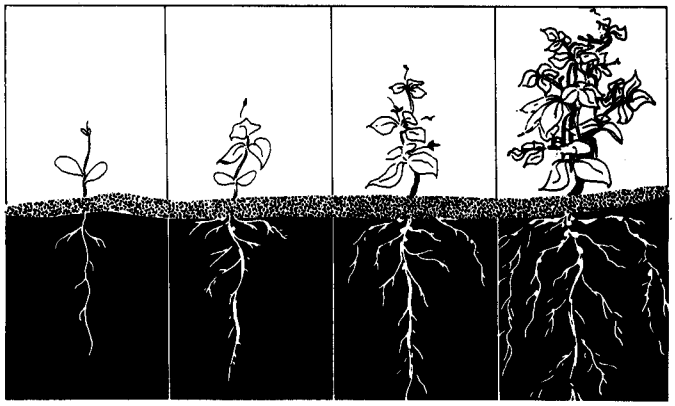
All living things require nitrogen to make proteins needed for life. Although nitrogen gas makes up about 80% of the air we breathe, most living things cannot use atmospheric nitrogen and require that it be combined or "fixed" with other elements like oxygen and hydrogen before it can be assimilated.

Animals get the nitrogen they need by consuming plant or animal protein, while most plants get fixed nitrogen from the soil. Because soils are often low in nitrogen content, good plant growth often means supplementing soil nitrogen with fertilizer nitrogen which is expensive to produce and is, therefore, too costly for many small farmers to buy. Fortunately, some plants can form mutually beneficial relationships (symbioses) with microorganisms which convert atmospheric nitrogen to ammonia. This "fixed" form of nitrogen is then used by the plants to make proteins. The name of this conversion process is biological nitrogen fixation or BNF.

How BNF Works



When the right rhizobia are present, legumes can fix nitrogen throughout their entire life cycle. Healthy plants and high seed yields are the result.



Can any plant form a symbiosis with a nitrogen fixing microorganism?

No. Only certain types of microorganisms and certain plants can form nitrogen fixing symbioses. For example, many species of the legume family form nitrogen fixing symbioses with common soil bacteria called rhizobia. This ability partly accounts for the high protein content of legume seeds--the main protein source for most of humankind. Cereals, the other major component of human diets cannot form nitrogen fixing symbioses. Many of the plant species that form nitrogen fixing symbioses are important in agriculture and forestry.

Can a plant get all the nitrogen it needs from biological nitrogen fixation?

Yes, in theory, but even nitrogen fixing plants will always take up some nitrogen from the soil. This is an important point to remember when intercropping nitrogen-fixing and non-nitrogen- fixing crops is being recommended to farmers. Although the nitrogen-fixing plant can produce some or most of its nitrogen, it can also compete with the non-fixing crop for soil or fertilizer nitrogen.

Do legumes that can fix nitrogen always do so?

No. In the case of a nitrogen-fixing legume, there must first be rhizobia bacteria and a susceptible legume plant present. In addition, appreciable quantities of nitrogen are fixed only by healthy plants. Therefore, other plant nutrients (for example, phosphorus and potassium), as well as the right environmental conditions (like soil moisture temperature, and salinity), must be optimum for good plant growth. Nitrogen fixation can only supply nitrogen to the plant, it cannot make up for other nutritional or environmental deficiencies.

If rhizobia are common soil bacteria, don't they occur everywhere?

No. There are many different types of rhizobia and not all types occur in all soils. This is important because certain plant species, like soybeans, will only form a nitrogen fixing symbiosis with certain rhizobia which may not be present in the soil in which the legume is to be planted. This situation occurs most often when a new crop requiring a specific type of rhizobia is planted in a field for the first time. Finally, though certain legumes such as cowpea for ex-

ample, can form nitrogen fixing symbioses with several types of rhizobia, they usually fix the most nitrogen with only one type.

How does one know whether the "right" rhizobia for a particular crop is in a field?

If ample numbers of nodules form naturally on a legume crop, one may conclude that the field contains native rhizobia that can nodulate that crop. If, upon cutting open the nodules, the inside is pink or red, one may also assume that the "native" rhizobia have formed an active nitrogen fixing symbiosis with that crop species. However, neither of these simple tests will tell whether the native rhizobia are the "best" (fix the most nitrogen) on that crop.

How can one insure that the "best/right" rhizobia establishes a nitrogen fixing symbiosis with a legume?

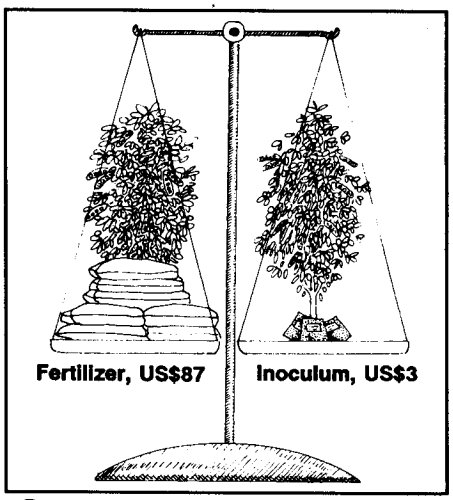
One can insure the maximum benefits from nitrogen fixation by inoculating the seeds with the "best" rhizobia. This insures that when the root emerges from the seed it is in immediate contact with the "right/best" rhizobia.

What is inoculation and how is it done?

Inoculation is the simple process of coating seeds with inoculant prior to planting. In the case of legumes, inoculant is a mixture of rhizobia and an inert material such as powdered peat. Alternatively, the inoculant can be placed in the furrows in which the seeds will be planted or banded alongside the seeds after planting. For additional information on when to use the different methods and for detailed instructions on how to inoculate, contact the NifTAL Project.

Is inoculant expensive?

Rhizobial inoculant is relatively inexpensive (see diagram below). It would take at least U.S.$87 worth of urea to produce a soybean yield comparable to that possible using only U.S.$3 worth of inoculant.



Cost comparison of inoculant vs. fertilizer nitrogen

How does one know if a legume crop is getting enough nitrogen from nitrogen fixation?

The simplest way is to plant one part of a field with inoculated seeds, one part with uninoculated seeds, and a third part with uninoculated seeds but then adding nitrogen fertilizer. By comparing the yields in the three parts, one can get an idea of whether nitrogen fixation is meeting most of the nitrogen demand of the crop.

However, remember that getting the most out of biological nitrogen fixation, whether for a grain or tree legume, requires that the best rhizobia for a particular plant species is either in the field or supplied to the plant via inoculation and that all other management conditions are optimal.

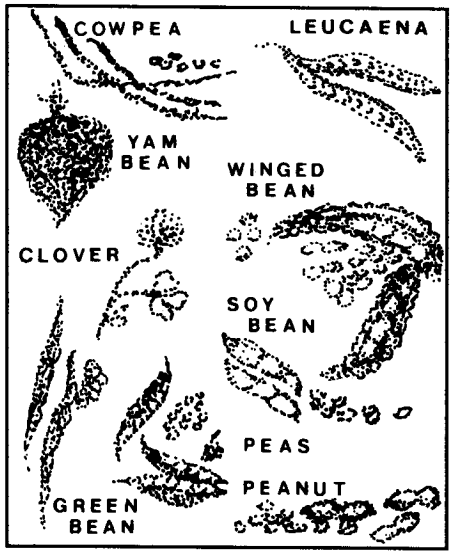
Where can inoculant be obtained?

Rhizobial inoculants for many crop legumes are manufactured in a number of countries around the world. The local agricultural extension agency or national departments of agriculture are the best places to seek information on whether inoculants are locally manufactured or have to be imported. Inoculants for tree legumes are not yet being commercially produced and so must be obtained from sources like NifTAL or other research or development agencies.

If there are no local sources of rhizobial inoculant where can it be obtained?

Contact NifTAL whose mandate is to supply small quantities of inoculant to all interested individuals for test purposes. Should sufficient local interest be generated, NifTAL can subsequently help national or regional institutions establish a BNF research program and/or examine the feasibility of establishing an in-country inoculant production capability.

Some Useful Legumes



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