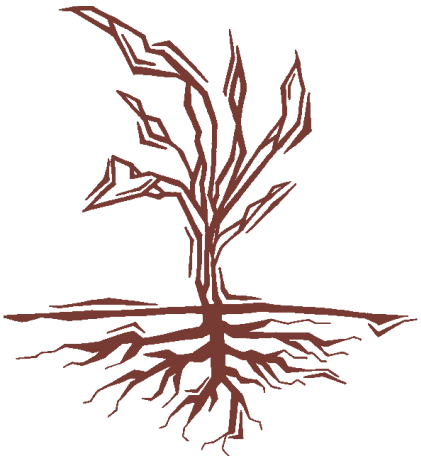

SOIL

Legume Seed Inoculants no. 0.305

by B. Erker and M.A. Brick [1]

Quick Facts...

Legumes convert atmospheric nitrogen to usable ammonia nitrogen for the plant.

Inoculation is the process of introducing commercially prepared rhizobia bacteria into the soil.

Each legume species requires a specific species of rhizobia to form nodules and fix nitrogen.

Store inoculum and preinoculated seed in a cool environment without exposure to sunlight.

Inoculum packages usually are labeled with an expiration date.

The air we breathe contains more than 78 percent nitrogen in the form of nitrogen gas (N_2). Legumes have the unique ability to form a symbiotic relationship with rhizobia (*Rhizobium* and *Bradyrhizobium*) bacteria to convert atmospheric nitrogen gas to ammonia nitrogen, a form usable by the plant. This relationship occurs in specialized root tissue called nodules. Some legumes, such as alfalfa, can produce enough ammonia to supply all their nitrogen needs (Table 1), hence nitrogen fertilization usually is not needed.

The relationship between the legume and rhizobia is symbiotic, or mutually beneficial. The bacteria invade plant root hairs and multiply in the outer root tissue. The plant forms tissue that acts as a protective enclosure around the bacteria. The plant also supplies energy to the bacteria from photosynthesis. For their part, the bacteria convert nitrogen gas to ammonia in the nodules.

Rhizobia species are identified by their ability to form nodules on specific legume species. Each legume requires a specific species and strain of rhizobia. Commercial inocula are labeled according to the plant species for which the rhizobia are highly effective. Successful nodulation and effective nitrogen fixation requires the correct inoculant.

Inoculation

Legume inoculation is the process of introducing commercially prepared sources of rhizobia to promote nitrogen fixation. This usually is done by applying inoculum directly to the seed prior to planting, or by metering the inoculum into the seed furrow during planting.

If the legume crop was grown in the field previously, there is a good chance that the soil already contains the correct rhizobial species for nodulation. However, native rhizobial populations found in soil often are less effective in nitrogen fixation potential. A nodule that is actively fixing nitrogen will be pink to reddish when cut open, rather than tan (ineffective) or green (dying).

Commercial inoculants are composed of rhizobial strains selected for maximum fixation potential. However, even when more efficient strains are introduced into the soil, there is no guarantee these strains will compete well with native strains for entry into plant roots.

Many studies have been conducted on the application of commercial inoculants into soils that already contain the correct rhizobial bacteria. In some studies, a significant yield increase has been observed. In other studies, no response occurred. Acid soils often have poor survival of the rhizobia. One way to evaluate the response of inoculants is to test several inoculants and an untreated control in fields using replicated strip tests. When in doubt about

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Table 1: Amount of nitrogen fixed per acre by several legume crops.

Crop	Estimates of nitrogen fixed per acre (lbs.) Low	High
Alfalfa	44	308
Cowpeas	44	132
Dry beans	50	150
Garbanzo beans	25	81
Peas	53	305
Soybeans	53	265

the rhizobial population in a field, it is a good practice to apply inoculum, especially if the legume has never or not recently been grown in that field.

Maintain proper soil fertility to ensure nodulation and nitrogen fixation. Some legumes normally get most of their nitrogen from the atmosphere through symbiotic nitrogen fixation. Attempts to supplement the legume nitrogen supply by fertilization usually are counterproductive, because plants tend to stop nitrogen fixation when soil nitrogen is high. Phosphorous and potassium can affect nodulation and nitrogen fixation. Research shows that additions of phosphorous and/or potassium increase the number of nodules formed, fresh weight of nodules, and amount of nitrogen fixed per nodule.

An important micronutrient for nitrogen fixation is molybdenum. Soils with a pH below 6.0 usually have low molybdenum availability. Other soils that could be low in molybdenum include those that are strongly weathered or leached, sandy soils, or soils high in manganese and iron. If molybdenum is a limiting factor, apply it as a seed treatment with the inoculum. Some inoculants have molybdenum already incorporated. Read the package label.

Commercial Inoculants

Three basic forms of commercial inocula are solid, liquid and freeze-dried. The most commonly used are solid, peat-based inoculants that can be purchased for seed or direct soil application. Liquid inoculants are available in broth culture or as frozen concentrate. Broth or frozen concentrates usually are mixed with water and sprayed into the seed furrow at planting. Because liquid inoculants must be kept frozen or refrigerated during shipment and storage, their availability through normal distribution channels is limited.

Seed-applied inoculants exist as planter box additives, preinoculated seed and custom inoculants. The planter box additive, where inoculant is mixed with seed in the planter box, is most common. This can be accomplished by applying dry inoculum or a slurry directly to seed. The dry method is least desirable because of uneven distribution and poor adhesion of inoculum to seed. The slurry is prepared by mixing the inoculum with water for better adherence to the seed coat. Seed also may be prewetted before mixing it with dry inoculants. Do not leave dry inoculum in the planter box overnight, or let it get wet from rain or dew.

Many small-seeded legumes, such as alfalfa, are preinoculated by seed conditioners, distributors and dealers. After conditioning, they apply a sticking agent to the seed, followed by the dry inoculum, or they incorporate the inoculum into a seed coating. Keep preinoculated seed in a cool environment during shipping and storage. Use the seed within one year of inoculation, or reinoculate it prior to planting. Rhizobia cells are living bacteria that must be kept viable until planting.

Custom inoculation usually is done on the farm or by the seed distributor. This involves application of a nutrient-rich adhesive formulation, followed by a peat-based inoculum. This method assures viable inoculum if seed is stored properly following application and used within one year.

Do not confuse seed inoculation with chemical seed treatment. Most seed disinfectants, including fungicides, are toxic to rhizobia bacteria. Do not apply inoculum to seeds that are treated with a bactericide, such as streptomycin, unless you use a resistant strain of the rhizobia. Although some rhizobia species are slightly tolerant to certain chemical compounds, inoculating chemically treated legume seed requires special precautions. Check with the inoculum manufacturer regarding combining products. Avoid inoculum products premixed with pesticides or other toxic chemicals.

Selecting the Correct Inoculant

Each legume species requires a specific species and strain of rhizobia. For example, the rhizobial species that nodulates alfalfa will not nodulate dry beans or soybeans. Plants mutually compatible with the same species of rhizobia were listed in earlier years in so-called "crossinoculation groups." With ongoing research, the demarcations between these plant groups has become less distinct. When selecting inoculum, consult your supplier and read the package label to be sure you select the correct inoculum for the crop.

Storage of Inoculum

Inoculum contains living rhizobial cells that survive on an organic carrier such as peat. The rhizobia population declines over time, even under proper storage conditions. Most inoculum manufacturers put an expiration date on the package. Do not purchase outdated inoculum. The rhizobial population may have declined significantly after the expiration date.

Optimum storage conditions for peat-base inoculum is under refrigeration. However, short term storage at temperatures below 60 degrees F is acceptable. It is best not to freeze peat-based inoculant. If it does freeze, do not leave it frozen any longer than necessary. Do not leave inoculants in direct sunlight. Ultraviolet rays and heat will kill the bacteria.

Purchase only the amount of inoculum or preinoculated seed needed for one planting season. When treating seed on-farm, avoid treating more seed than can be planted in one day. Inoculant packages provide information regarding the amount of seed or furrow that can be treated with a measured amount of inoculum.

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