

RHIZOBIA AND NITROGEN FIXATION

Rhizobia are a group of common soil bacteria that form small growths—or nodules—on the roots of legumes. Rhizobia bacteria are important because they convert nitrogen gas from the atmosphere into a form of nitrogen that is readily used by plants (a process called nitrogen fixation). For more on nitrogen fixation, see NMSU Extension Guide A-129, *Nitrogen Fixation by Legumes* (http://aces.nmsu.edu/pubs/_a/A129.pdf).

Rhizobia are not toxic to humans, plants, or animals. They are some of the most beneficial bacteria to agriculture. Some rhizobia form nodules only on specific legumes, while others may nodulate several legume species. Soil may contain enough native rhizobia to nodulate both native and introduced legumes. Often, however, the native rhizobia are low in numbers, are the wrong species or strain for the introduced legume, or are not efficient nitrogen fixers. Inoculation usually corrects these problems.

Nitrogen fixation in legumes depends on the formation of nodules by rhizobia. Without sufficient nodule mass filled with an efficient, nitrogen-fixing strain of rhizobia, nitrogen fixation will be inadequate. Inoculating legume seed ensures rhizobia are present in the root environment in sufficient numbers.

IS INOCULATION NECESSARY?

Growers must decide before planting if they need to inoculate. The following considerations should help you decide if inoculation is necessary.

Inoculation is recommended if

- the legume to be planted was never grown or hasn't been grown in the field for more than five years;
- the legume was grown but you don't know if it was well nodulated or how efficient nitrogen fixation was; or
- the land was never in cultivation (native desert or rangeland).

If any of these conditions apply to you, the native rhizobia are probably not present in sufficient numbers to adequately nodulate the crop, or they may not be efficient in fixing nitrogen. Inoculation is inexpensive (about \$1–5 per acre) compared to the expense of replanting.

Inoculation should be redone if the legume was previously grown but nodulation or nitrogen fixation was poor (as indicated by poor yield and nitrogen deficiency symptoms). However, plants are affected by a host of other potential problems that can cause poor yield (insect, disease, weather, water, or plant nutrition problems). If the field was inoculated and poor nodulation or poor nitrogen fixation was observed, eliminating plant stresses may also increase nodulation and nitrogen fixation.

If the legume was grown previously and was well nodulated and nitrogen fixation appeared adequate (as indicated by good yield and no nitrogen deficiency symptoms), there is probably no need to inoculate. Once rhizobia are established in a field, they persist for several years between crops. There is no yield advantage to yearly inoculation of legume crops in fields where the well-nodulated legume is routinely grown. Also, once a particular strain of rhizobia is established in a field, it is difficult for another strain to establish itself. The established strain is usually more competitive for nodulation sites on the plant than an introduced strain.

If surrounding fields are planted or have been planted to the same well-nodulated legume, there is often no need to inoculate. Rhizobia will spread to nearby fields after years of legume production. Alfalfa grown in the Mesilla Valley is a good example.

INOCULANT TYPES AND SUPPLIERS

Several inoculant types are available, including powder, granular, liquid, and frozen concentrate; pre-inoculated legume seed may also be available. The powder and granular inoculants are the most common, while liquid and frozen concentrates are used for special purposes.

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Powder inoculants are the most common and most reliable. They have been around since the turn of the century and are simply stuck to the seed before planting. Powder inoculants are available for all types of legumes and are the least expensive to use (less than \$2 per acre). The black, or occasionally tan, powder contains approximately one billion rhizobia per gram.

Granular inoculants are available for large-seeded legumes, including beans, soybeans, and peanuts. They contain about the same concentration of rhizobia as the powder inoculant, but may cost two to three times as much. Their particle size is larger than powders, which allows the inoculant to flow through an insecticide, fertilizer, or similar planter attachment. Although the cost may be higher, the inoculant can be distributed by the planter attachment, and no seed mixing is required. Granular inoculant is particularly useful when pesticide-coated seed is planted or when excessive seed handling can damage the seed coat, as with peanuts.

Pre-inoculated seed is worth the extra cost (compared to uninoculated seed) only if the inoculant is freshly added and the seed quickly planted. This is not generally the case in New Mexico. Rhizobia are living organisms and will not survive long if left exposed to air, heat, cold, or light. If inoculation is considered necessary, use the methods discussed in the *INOCULATING A LEGUME CROP* section of this guide and don't waste money on pre-inoculated seed.

Liquid inoculants are better than those available a decade ago, and they are certainly much easier to use than the powder inoculants. However, be particularly alert to the expiration date and handling of the inoculant by the dealer. Improper handling can kill rhizobia.

Several companies produce legume inoculants, and you can find them via the internet or by visiting your local fertilizer or seed dealer. Agricultural suppliers will typically only sell by the case. However, they can be contacted directly and may supply a grower or supplier when asked. They sell inoculants under several brand names. The two suppliers that serve New Mexico are:

BASF/Becker Underwood Inc.

1-800-892-2013

request@beckerunderwood.com

<http://www.agro.basf.com/agr/AP-Internet/en/>

Novozymes Bio Ag

agriculture@novozymes.com

<http://www.novozymes.com>

1-888-744-5662

Sales representative for OK, TX, NM

genm@novozymes.com or 1-806-315-0569

For home gardeners, many garden seed companies offer small quantities of powder inoculants for a variety of garden legumes. These are usually called garden packs and contain several types of rhizobia for most commonly grown garden legumes.

INOCULANT PURCHASING AND HANDLING

Rhizobia inoculant is a living culture of bacteria and must be handled as such. Rhizobia are particularly sensitive to heat, desiccation (drying), and light. Many inoculant failures can be traced to improper purchasing and handling of the inoculant. If the inoculant is handled as a fertilizer or pesticide, either by the grower or supplier, the rhizobia will likely be dead before they reach the seed. Inoculant should be stored in a cool area away from desiccation and heat and refrigerated if it will be stored for some time. Pesticides and some fertilizer coatings may kill rhizobia when applied directly to the seed. Always make sure the inoculant label contains the following critical information: type of legume, quantity of seed (powder) or acreage of land (granular) the package will inoculate, and expiration date.

The rhizobia species must match the legume species. Alfalfa inoculant will not work on beans and bean inoculant will not work on alfalfa. Powder legume inoculants should indicate how many pounds or bushels of seed the inoculant will cover; never use less than the recommended amount of inoculant for the given quantity of seed. If conditions are particularly hot or dry when planting, if the inoculant is old or has been stored improperly, or if the land has never been cultivated with legumes, then double the amount of inoculant per quantity of seed. Adding double, triple, or 10 times the recommended rate will not affect the environment or seed. Granular inoculants are labeled to indicate how many acres the inoculant will cover. Adding more than the recommended rate is much more costly with granular than powder inoculants.

The expiration date is critical because inoculants are living cultures and their viability decreases with time. Never buy an inoculant that has passed its expiration date, or that has been stored improperly by the supplier, such as in a chemical or fertilizer warehouse.

INOCULATING A LEGUME CROP

When inoculating with a granular inoculant, simply follow the label instructions. Never allow the inoculant to remain in a planting attachment in the hot sun for long. Remove unused inoculant from the attachment, seal it in the original bag, and store in an area protected from heat and sun.

Powder inoculants require more handling. They must be securely stuck to the seed, and the seed must be planted immediately. Commercial stickers are available that help stick the inoculant to the seed. You can make your own sticker by preparing a sugar solution of 1 cup sugar to 1 quart of warm water. Slightly moisten the seeds with a small amount of sticker solution and mix with inoculant. Only a small amount of liquid should be used to prevent the seeds from getting too wet. A small cement mixer mixes the seed and inoculant uniformly. Pouring seeds and inoculant between clean 5-gallon buckets also works well. After mixing, all the seeds should be evenly covered with small specks of inoculant. Plant the seeds immediately, making sure the inoculated seeds are not exposed to sunlight. If the seeds become too dry, the inoculant will come off. If large quantities of seed are to be inoculated and stored for several hours or overnight, put the inoculated seeds back in the original seed bag, add a moistened paper towel and close tightly. Simply pouring inoculant on top of seed in a planter will result in poor inoculation.

Other factors that affect the legume–rhizobia symbiosis include soil temperature at time of planting, soil water content, sodicity, salinity, and plant nutrient disorders. At one time inoculants were made with a non-sterile peat

carrier, which can carry pathogenic bacteria such as *Pseudomonas aeruginosa* that can inhibit the growth of some inoculants. Following proper storage techniques, securing a valid soil test, and choosing the right inoculant for the crop of interest are important for success.

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