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Inoculation of Agronomic and Forage Crop Legumes [1]

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Inoculation is the process of applying *Rhizobium* bacteria to legume seed to form a symbiotic relationship with the developing plant. Bacteria (*Rhizobium* and *Bradyrhizobium*) are capable of fixing atmospheric nitrogen (N) into forms usable by plants. The N-fixing bacteria are of two general kinds—symbiotic and non-symbiotic. The non-symbiotic group consists of free-living organisms, whereas the symbiotic group cannot function without the aid of a host plant. The association between the host plant and the symbiotic bacteria is mutually beneficial in that the plant furnishes the necessary energy, and the bacteria uses this energy to fix atmospheric N that can be used by the host plant.

With a few exceptions, the plants with which the symbiotic N-fixing bacteria are associated belong to the legume family. The development of nodules on the roots of a legume is evidence that the symbiotic bacteria are present. Since the symbiotic organisms are usually associated with legumes and result in the formation of nodules, the organisms are often called "legume bacteria" or "nodule bacteria." The bacteria genus "*Rhizobium*" is the common "legume bacteria."

Methods for "inoculating" seeds include: 1) Applying a commercially prepared culture of the proper strain of bacteria to the legume seed or in the seed furrow at planting, or 2) spreading soil from a field in which the legume recently has become inoculated and has grown successfully. However, the disadvantages of using soil outweigh the advantages to such an extent that commercial cultures are generally used either on the seed or sprayed in furrow or a similar manner.

Many commercial inoculants are in a powder form and consist of finely ground peat mixed with the N-fixing bacteria, which are intended for mixing with the seed. Granular formulations of the peat-bacteria mixture are designed to be placed in the seed furrow at planting. Liquid inoculants and other non-peat-based inoculants are also being used where equipment is set up to apply in the seed furrow with the seed. It has generally been noted that peat as a carrier for the bacteria provides more protection and prevents drying and death of the bacteria, compared to the inoculants that do not contain peat.

Several species of legumes may be inoculated by one type of bacteria. These are called cross-inoculation groups. In some cases, only one species of legume may be in a cross-inoculation group. Table 1 lists the legumes in various cross-inoculation groups. To purchase the proper inoculant, find the legume to be planted and then order the inoculant for that cross-inoculation group.

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When using commercial inoculants, the following rules for successful inoculation should be observed:

1. Purchase fresh inoculant from the proper cross-inoculation group. Before completing purchase, note the expiration date printed on the container and make sure that the bacteria culture is of a strain that will inoculate the legume to be planted. See Table 1 for legumes included in each cross-inoculation group. Store culture in a cool, dry place until it is to be used.

2. Inoculate if there is any doubt as to whether bacteria of the proper strain are present in the soil. If peanuts or soybeans have a long history of being planted in the field, less response to inoculants may occur.

3. For powder inoculants, follow directions for each crop. Put a sticking compound on the seed, then add inoculant and mix well with seed. If seed becomes too wet, allow to dry before putting into a seed hopper for planting. Do not allow direct sunlight to hit the inoculated seed. During planting apply granular or liquid inoculants in the seed furrow at the manufacturers' recommended rates.

4. Do not allow seed to contact caustic lime or soluble fertilizers. Some seed-protecting chemicals are incompatible with legume bacteria. Molybdenum may aid in nodule formation on soybeans planted on mineral soils that have not been limed to the optimum pH. Do not purchase inoculant pre-mixed with molybdenum because the bacteria may die in such pre-mixes. If needed, these materials should not be mixed with the inoculant until just prior to planting.

5. Plant inoculated seeds at once (within four hours) into moist soils and cover them immediately. Most planters have press wheels that pack the soil for good soil-seed contact which is important for fast germination and survival of the bacteria.

6. Plant when both soil temperature and moisture are favorable for quick germination of the legume and favorable for the survival of the bacteria.

Table 1. Cross-inoculation groups of field and forage crop legumes.

ALFALFA GROUP		
Alfalfa Black medic Bur-clover	Buttonclover Fenugreek	Sourclover Sweetclover
BEAN GROUP		
Garden bean Kidney bean	Pinto bean Scarlet runner bean	Wax bean
CLOVER GROUP		
Alsike clover Arrowleaf clover[1] Ball clover Berseem clover Crimson clover	Hop clovers Ladino clover Persian clover Red clover	Strawberry clover Sub clover White clover Other true clovers
COWPEA GROUP		
Aeschynomene Alyceclover Beggarweed Bushclover Cowpea Crotalaria	Guar Hoary tickclover Indigo Kudzu Lespedeza Mung bean	Partridge-pea Peanut Pigeonpea Savanna Stylo Stylosanthes humilis Velvetbean Carpon Desmodium
LUPINE GROUP		**SOYBEAN GROUP**
Lupine	Seradella	Soybean
VETCH AND PEA GROUP		
Austrian winter pea Field pea Garden pea	Horsebean Lentil Rouph pea	Sweet pea Tangier pea Vetch

The following legumes appear to require specific strains of nodule bacteria for effective inoculation: *big trefoil, birdsfoot trefoil,* and *sesbania*. Special orders may be needed to locate effective bacteria.

[1] All legumes within a group can be inoculated with the same culture or kind of nodule bacteria. Some of the inoculants for clover may not be effective in N-fixation by arrowleaf clover although nodules form. Use inoculant that is specifically for arrowleaf clover.