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Inoculating Alfalfa and Clover Seed

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Legume plants with no nodules or with nodules containing ineffective bacteria are common causes of low production or complete failures of alfalfa and clover plantings in Oregon. These failures result in the loss of the stand plus the investment in fertilizer and seed used to make the planting. In many cases these problems have resulted from failure to follow the basic rules of legume seed inoculation.

Nitrogen fixation is important

Nitrogen is essential to plant and animal nutrition, as it is a vital ingredient of protein and other essential materials. The atmosphere contains about 80 percent nitrogen by volume. This vast amount of free atmospheric nitrogen is unavailable to most plants or animals. It can be converted to a usable form by legume plants such as alfalfa or clover when they are growing in association with *Rhizobia* bacteria. These bacteria grow within modified parts of the plant roots called nodules. The bacteria use food energy obtained from the legume root and convert gaseous atmospheric nitrogen into compounds which can be used by both the bacteria and the legume plant. This process is known as nitrogen fixation. The bacteria and the host legume both benefit from this symbiotic relationship whereby the legume receives its nitrogen from the bacterial by-products and the bacteria receive portions of their food supply from the legume and have a protected growth environment within the nodule. As the nodules mature and the roots decay, nitrogen by-products are returned to the soil with a net increase in nitrogen fertility. When legumes are grown for hay, much of the fixed nitrogen is removed from the field in the forage.

Alfalfa and clover cannot be grown economically without effective nodulation.

Bacteria invade the legume root

The *Rhizobia* bacteria enter the legume through the root hairs on the young roots. This may occur as early as 4 to 12 days after seed germination. The original infection rapidly develops into visible nodules three to five weeks after seeding emergence, depending on the species and growth rate.

Not all *Rhizobia* are the same

Legume bacteria are of different kinds. Bacteria that fix nitrogen on alfalfa and sweetclover will not fix nitrogen on clover, peas, and other legumes. Commercially prepared inoculant cultures are available for *specific crops* and must be so utilized. The correct culture must be used when inoculating legume seed.

Certain strains of legume bacteria are more efficient in fixing atmospheric nitrogen than others. Therefore, it is important to establish conditions that will permit root infection by the most efficient strains of bacteria. Nodules formed on legume roots by effective bacteria are large and the interior has a rich red color when compared with the smaller and paler ineffective nodule. The development of highly effective nodules will inhibit root infections by other strains of bacteria. Initial infection by ineffective strains will preclude invasion by effective Rhizobium. *For most successful nodulation, it is important that the original infection result from a most efficient nitrogen-fixing strain.* Chances for infection by desirable strains are improved by surrounding each legume seed with large numbers of viable *Rhizobia* of desirable strains and creating soil conditions most favorable for their survival.

Conditions affecting successful inoculation

Bacteria placed on the seed before planting must survive for several weeks until seed germination and root hairs are developed so that infection can take place. During this time, the number of bacteria on the seed may be reduced greatly or even depleted, resulting in failure of nodules to develop. Several conditions reduce the number of bacteria:

- **Exposure to sunlight and drying** are two conditions that often occur together. Seed may be exposed to sunlight (ultraviolet rays) after inoculation and before planting. Broadcast seed is exposed to sunlight. Drying conditions are often common in poorly compacted seedbeds, which lose soil moisture readily. Avoid this problem by drilling the seed into moist soil or just ahead of a rain. Pelleted seed consisting of inoculum, adhesive, and lime is helpful when seed is exposed to light and drying conditions.

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• **Exposure to high temperatures** may occur any time during storage by the wholesaler, retailer, or grower. The inoculum should be stored in the refrigerator at a temperature *above* freezing. Inoculated seed often is exposed to high temperatures when seeded in dry soils during summer months.

• **Unfavorable soil conditions** such as acidity, low fertility, and the presence of antibiotic substances are common. Liming of acid soils and a good fertility program help overcome these problems.

• **Banding seed in contact with acid fertilizers** or with heavy metals such as boron, zinc, or molybdenum, applied as micronutrients, may destroy *Rhizobia.* Proper band placement at seeding time will prevent seed contact with the fertilizer materials.

• **Age of the inoculum** affects the number of bacteria. All commercial inoculants are dated. Old inoculants should *not* be accepted.

Adverse soil and planting conditions can be partially overcome by application of a greater number of *Rhizobia* bacteria to increase the probability that enough bacteria will survive until roots are developed and infection can occur. A very large number of bacteria may result in successful nodulation where a smaller number will be a failure under the same conditions. This explains some of the apparent erratic results with legume nodulation.

Commercial inoculants

Several types of commercial inoculants are available. The dry peat cultures have proven most successful. They have a good shelf life when properly stored and are easy to handle at planting time. Outdated packages of inoculant should not be accepted.

Pre-inoculated seed

Pre-inoculated seed has been marketed for several years. Results from its use have been variable. The use of additional inocu'ant at seeding will provide cheap insurance and reduce the risk of failure in legume establishment.

Steps for seed inoculation

Successful legume inoculation will result from following a few simple steps and providing suitable soil pH and physical conditions.

• Use inoculants specifically labeled for the legume you are treating. Generally, mixtures of strains of bacteria are not as effective as preparations labeled for only one specific legume.

• Use only fresh, age-dated inoculant purchased from dealers who store their supplies in cool, dark places to minimize deterioration. Best storage conditions are provided by refrigerators with temperatures just above freezing.

• Store the inoculant in a refrigerator until used.

• Dampen the legume seed, using as little liquid as possible. Approximately one pint of liquid per 100 pounds of seed is required. Whole, condensed, or skim milk can be used as an adhesive. Mix the seed and liquid thoroughly until every seed is moist but not wet enough to cause the seeds to stick together. Do not use containers or mixtures contaminated with seed disinfectants or fertilizer materials which might be toxic to legume inoculants.

• Add the inoculant to the seed in small quantities until at least the amount recommended by the manufacturer has been applied. Mix thoroughly until every seed has come into contact with the inoculant. When planting under conditions which are not ideal, increase the inoculant rate.

• Be sure that inoculated seed does not come into direct contact with the fertilizer.

• Plant seed into a well-prepared, firm seedbed *immediately* after inoculation. Avoid exposing the seed to sunlight, severe drying conditions, or high temperatures. If seed is not planted within 24 hours, repeat inoculation step because previous treatment may have been destroyed by drying.

• When planting, leave seedbed surface packed to minimize exposure of seed to sunlight and drying conditions. Broadcast seedings should be covered and firmed by a cultipacker or roller.

• Plant just before a rain or into soil with a good soil moisture condition. Cultipacking the soil after seeding will help to maintain moisture near the seed.

When nodules fail to develop

Improperly nodulated legume stands can be identified by light yellow foliage. Entire leaf surfaces turn yellow, with symptoms first appearing on the lower leaves. These symptoms are caused by nitrogen deficiency. Verify the diagnosis by comparing the size and color of the nodules with those of a healthy plant. Sulfur deficiency also causes a yellow coloration of the alfalfa leaves, and this may be confused with a nitrogen deficiency due to poor nodulation. However, the younger, upper leaves turn yellow first on sulfur-deficient plants.

If a perennial legume seeding contains a few well-nodulated plants, the stand may be salvaged by fertilizing lightly with nitrogen to maintain the non-nodulated plants temporarily with a possibility that they may develop effective nodules. Continued application of nitrogen to maintain a stand is not recommended. Applying fresh inoculant through irrigation water or spray application during a rainy period has not generally been effective to correct a poorly nodulated stand.

Summary

For successful legume nodulation:

- Correct soil acidity with lime application
- Fertilize to correct soil nutrient deficiencies
- Prepare a fine, firm, moist seedbed
- Select the correct inoculant culture for the legume
- Store the culture in a cool, dark place until used
- Mix culture thoroughly with dampened seed
- Plant seed immediately after inoculation
- Do not drill inoculated seed directly with fertilizer
- Cultipack the soil after seeding