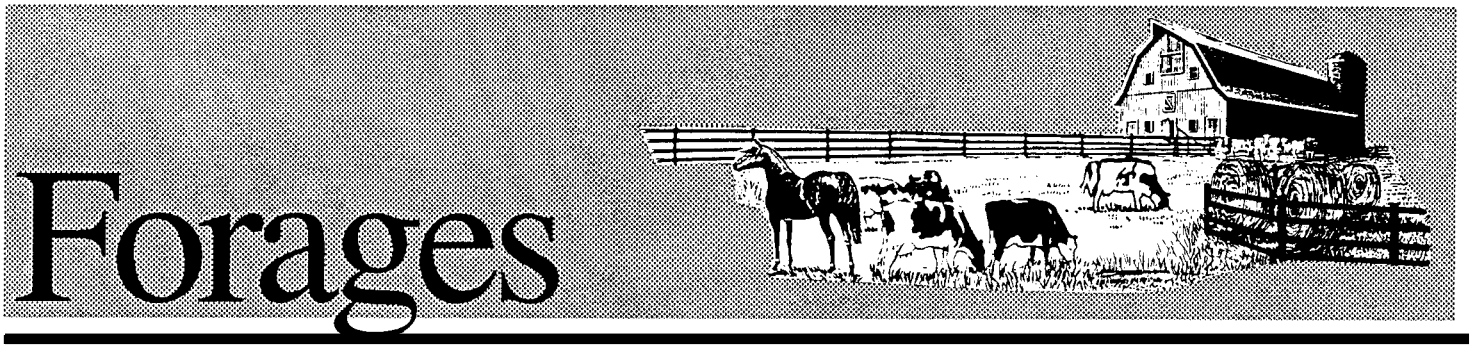

FORAGE LEGUME INOCULATION

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Legumes are the highest-quality livestock forage available. Most forage legumes are herbaceous (non-woody), broadleaf (non-grass) plants such as alfalfa, annual and perennial clovers, and the lespedezas. Although there are many shrub and tree type legumes in the world, some of which are utilized for browse or forage, none is currently utilized for forage in South Carolina.

Legumes are plants that bear their seed in a pod. The most commonly recognized legumes include garden peas and beans, soybeans, mimosa, and locust trees. Although legumes play a critical role in human nutrition, nitrogen fixation is the attribute of most legumes that is important in forage production.

The air we breath is 80% nitrogen, and most legumes are able indirectly to obtain nitrogen from the air. Bacteria, called rhizobia, can live in the nodules on legume roots and can extract nitrogen from the air for its own use. Some of this nitrogen is made available to the plant. This results in two very desirable aspects of forage legumes: 1) nitrogen almost never limits crop growth; and 2) no or minimal nitrogen fertilization is required.

The Plant/Microbe Relationship

Nitrogen supplied by rhizobia is often referred to as free nitrogen. In return for the nitorgen, however, the rhizobia receive energy from the plant in the form of carbon. A symbiotic relationship exists where both species benefit. Since plants pull carbon out of the air, in the form of carbon dioxide, the energy supplied to the rhizobia is seldom a noticeable drain on the plant, although it can approach 20% of the energy fixed by the host plant.

Understanding the nodulation process (how the rhizobia infect and become established in the plant root) is important because successful inoculation depends on effective management practices. Soon after a legume seed germinates we see the top growth as the first one or two shoots. The first roots are also pushing down into the soil at this time. Root and shoot growth continue concurrently. As the roots grow in length, they also are developing nodulation sites. Rhizobia can enter the nodulation site and reproduce as soon as roots begin to develop. This is called the nodulation process. After three to four weeks a fully developed nodule can be formed.

The process of nodulation will proceed voluntarily if rhizobia are present in the soil. However, that is not always the case, and the simple procedure of seed inoculation ensures that the correct rhizobia are present so that nodulation can occur. The following points should help explain the complexities of the system and help explain how proper inoculation procedures can have a substantial impact on the amount of nitrogen that is made available to the forage plant, and thereby the amount of crude protein to the grazing animal.

1) There are thousands of different types of rhizobia.

2) Native rhizobia live in the soil.

3) A particular legume plant requires a certain type of rhizobia for optimum nitrogen capture.

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4) Three things can happen with the nodulation sites on the plant roots (two of the three are bad for the forage producer).

   a) **No nodulation:** no rhizobia that are present are capable of nodulating the site, so no nodules are formed.

   b) **Ineffective nodulation:** a nodulation site is occupied by rhizobia that do not fix nitrogen. A nodule is formed and the rhizobia will extract carbon from the plant, but no nitrogen will be fixed. In this case the rhizobia may even extract nitrogen from the plant.

   c) **Effective nodulation:** a nodulation site is occupied by rhizobia and a nodule is formed, and the rhizobia do fix nitrogen.

5) There are strains of rhizobia that produce effective nodules, but that differ in the amount of nitrogen that they will fix.

6) Rhizobia are affected by soil pH and fertility status, particularly by phosphorus, potassium, calcium, and magnesium.

The relationship between the legume plant and the nitrogen-fixing rhizobia bacteria is complex. However, a general understanding, as presented above, should help you recognize the need for certain steps and/or activities when establishing a pasture or hay field with a forage legume. The $3 to $5/acre input for the correct inoculum (rhizobia), and the added labor, is a small price for the 100 to 300 pounds of nitrogen/acre that the rhizobia can provide to the forage plant.

The Inoculation Procedure

The object of the inoculation procedure is to "stick" up to 100,000 rhizobia to the legume seed prior to planting it. This number is necessary to ensure that a few of the correct rhizobia are present in the vicinity of the root when the nodulation sites are developed by the plant. The soil, particularly a very dry soil, is a hostile environment for the rhizobia which have to live outside the nodule, waiting for the plant to develop.

The idea of rhizobia "fighting" for a place to survive should help emphasize that these are living organisms and have certain requirements to maintain viability. This is the reason an ***inoculating system*** is stressed rather than just the inoculant. Consider these four points:

1) If at all possible, purchase your ***inoculating system*** from a dealer that has maintained the inoculum in cool storage, or at the very least, in a shaded, protected area.

2) Keep the inoculant out of the sun as you transport it to your operation. Optimally, store the inoculum in a refrigerator (not in the freezer!), or at least in a reasonably cool, shaded area until use. If stored in a refrigerator, remove the inoculant about 24 hours before you intend to use it and let it slowly warm to room temperature. Do not expose inoculant to sunlight.

3) Perform the actual seed inoculation process in the shade, and do not inoculate more seed than you can plant in a reasonable time period. Keep the inoculated seed out of direct sunlight!

4) Plant quickly, to the optimum depth for the particular legume. Chances of success are increased if planting is done when adequate soil moisture is present or just prior to a rain. Seeding into a dry soil can lead to poor survival of the rhizobia and no nodulation or ineffective nodulation.

Several companies produce inoculum and inoculating systems for forage legumes. Purchase an inoculant specifically recommended for the legume you are planting: i.e., an alfalfa inoculant for alfalfa, a white clover inoculant for white clover; as discussed previously, there are differences, both in whether or not nodulation will occur and in the amount of nitrogen fixation that will occur. Inoculant packages should be labeled. Particular attention should be paid to clover inoculates. For example, both red and white clover use type "B" inoculant; arrowleaf clover requires type "O"; while crimson and berseem clovers require type "R" inoculant. A bag labeled "Clover Inoculant" would contain rhizobia for several clover species, but probably not the optimum for any one species. Furthermore, there is always the possibility of ineffective nodulation.

Although legume species require different inoculants, cultivars of the same species use the same inoculant. For example, there is a specific inoculum for arrowleaf clover; however it is the same for Yuchi, Meechee, or Amclo arrowleaf clover.

Guidelines for Inoculation

Most inoculum is peat-based. Rhizobia are carried in a finely ground peat, which gives the inoculum its black color. A complete inoculating system supplies the inoculum, sticker (a glue-like substance to stick the rhizobia to the seed), and requires mixing with water. Some companies provide a mixing bucket and measuring cups with the systems. Each system comes with specific instructions. The following are general guidelines:

1) Obtain a tub or other container large enough to hold the seed to be inoculated, and rinse it out. A rubber or plastic tub will be less likely to push slivers of metal up under your finger nails as you are mixing. Gather your seed, inoculating system, and something comfortable to sit on.

2) Find a shade tree preferably near a water hydrant, or obtain about a gallon of cool, clean water — cool so you do not boil the rhizobia, and clean so you can have a drink as you work.

3) Read the instructions on the inoculating system. Have a drink of water and ***read the instructions again.***

4) Pour the amount of seed that you will be planting into the tub, using a known or measured quantity of seed.

5) For most inoculating systems you will mix the rhizobia/peat with a measured amount of water to form a slurry. Use the exact amount of water called for; do not get the seed too wet or they will bridge in the hopper of your planter.

6) Next add the sticker, or sticking agent, to the water/rhizobia mixture and stir well (or, in one system, sprinkle the sticker on the seed in the tub and mix well).

7) You are now ready to add the slurry to the seed and mix well to spread the slurry uniformly over all the seed. This step is facilitated by adding the slurry a little at a time, using three to four applications before all the slurry has been utilized.

8) Make sure all seeds in the tub have been mixed and are uniformly coated with the inoculant slurry. There is no neat way to do this and you will get dirty.

9) Typically inoculating systems advise you to let the seed dry, ***in the shade***, for about an hour. This should ensure a dry, flowable seed/rhizobia mixture that will feed through the seeder with no problems.

   Helpful hint: If you have gotten the seed too wet, add a little lime to the mixture and mix it in well. Lime will absorb water and does not hurt the plant at all; if anything it will help by raising the pH in the immediate area surrounding the seed.

10) Plant into a well-prepared seedbed limed to pH 6.5 to 7.0 with phosphorus and potassium applied according to a soil test recommendation.

A few more points to note:

1) Placing the seed in the planter hopper and pouring the rhizobia/peat on the seed is a waste of time! Don't bother getting the seed hopper dirty.

2) Mixing the rhizobia/peat with water, **with no sticking agent**, and mixing with the seed is also a waste of time and effort.

3) Using sugar-water, a coke, or syrup and water as the sticking agent will not be as effective as the commercial sticking agent.

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