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Questions and Answers about *Rhizobium* and Inoculation for Peanuts

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The following comments were shared with Peanut Grower magazine for a recent article on *Rhizobium* inoculation for peanuts. Research and experience with inoculants obtained at Western Peanut Growers Association Research Farm contributed to this article.

I note first that *Rhizobium* issues take a different twist in Texas due to the high pH soil conditions, especially in the Texas South Plains. South Plains soils are very sandy, and in particular pH is high, always above 7.2, sometimes as much as 8.3 when geologic calcium carbonate, or caliche, is present. In the Southeastern U.S. many if not most growers do not inoculate their peanuts as they receive adequate carryover *Rhizobium* and nodulation from previous peanut crops. This is often the case in Central and South Texas as well. I would imagine that growers planting on soil that has been out of peanuts the last four crops might apply the inoculant.

One thing I will mention for clarification: we usually speak of *Rhizobium* for simplicity, but in fact it is *Bradyrhizobium* for peanuts. Most legumes nodulate with *Rhizobium* infection, but the specific inoculant for peanut is *Bradyrhizobium*.

The two main N inoculant companies in the U.S., Liphatec, Milwaukee, Wisconsin, and Urbana Laboratories, St. Joseph, Missouri, market a wide variety of crop-specific inoculants for legumes such as peanut, soybean, clover, alfalfa, etc. For many crops growers can choose between seedbox, granular, or liquid inoculants. In general, a grower can reasonably expect that the liquid inoculants deliver larger numbers of *Rhizobium* to the seed (then granular, and lastly seedbox inoculants). Under optimum conditions seedbox inoculants may be adequate, but those conditions are not always present, and I rarely see satisfactory results with seedbox inoculants in West Texas. Seedbox inoculants can desiccate and lose viability if not applied properly. The seedbox inoculants are less able to handle (survive or at least work efficiently) adverse conditions such as heat, sandy soils, chemically active soils, or acid or calcareous soils. And to use the seedbox inoculant properly, the seed should be wetted, and when a farmer is planting 90 lbs. per acre, it is too much work. And if an air-vacuum planter is used and unwetted seed is planted then the inoculant can blow off.

The above companies have websites at http://www.liphatec.com and http://www.urbana-labs.com Both companies publish data from all over the peanut belt demonstrating results on various inoculants, some in conjunction with various states' research and extension units. Much of the data presented, however, may have no statistical measures evaluation, so I can't speak to whether some of the differences presented would pass the research and statistical tests.

How do inoculants promote nitrogen fixation? (What is the science behind using inoculants?)

Crop rotation, which includes legumes, offers the grower the welcome opportunity to take advantage of the nitrogen-fixing relationships between N-fixing bacteria and their symbiotic relationship with a host legume. This biological symbiotic relationship is a 'you-scratch-my-back, I'll-scratch-yours' arrangement whereby the plant supplies an environment, nutrients, and organic substrate in which the microbial *Rhizobium* can grow and thrive. In turn, the *Rhizobium* 'fixes' or reduces atmospheric nitrogen, N_2, to a form the plant can use. This process of nitrogen fixation of N_2, which has a very strong chemical bond (witness the high energy requirements to make synthetic nitrogen fertilizers!—that's why when fuel prices are high that N fertilizer costs go up), can be broken and the nitrogen assimilated into forms usable by the plant. In essence, this is "free" nitrogen. Inoculation introduces tremendous numbers of bacterial cells of a specific strain or strains of particular *Rhizobium* or *Bradyrhizobium* to the soil environment in close contact with legume seed and roots where infection, the initiation of the symbiotic relationship, may occur. Often strains of *Rhizobium* are normally already present in the soil, but their numbers or their specificity to a particular legume are usually far less than optimum.

When should inoculants be used?

In general, legume crops should always be inoculated the first time they are planted on a field or if it has been 5 years since that legume was grown there before. Adverse soil conditions and cropping history should guide whether N-fixing inoculants should be applied in subsequent years. In West Texas, even though we don't always get the desired mass of *Rhizobium* nodules on the taproot (I call it 'supernodulation'), we recommend peanut growers use a *Rhizobium* inoculant every time they plant peanuts. The bottom line is inoculation helps ensure that the crop has the mass of specific *Rhizobium* bacteria present for adequate infection and increased yield potential. In West Texas, the process is reliable most of the time, but reduced nodulation may occur due to hot dry soils that may desiccate the bacteria, misapplication of inoculant, or other factors that we don't yet understand. The worst case, however, is to have a field without nodules. It appears we have little carryover of *Rhizobium* inoculum in West Texas peanut soils thus there is added impetus to inoculate.

Just to contrast a different area of the peanut belt, in South Texas south of San Antonio we have about 20,000 acres of peanut production. Past research has demonstrated little benefit to inoculation unless the field has been out of peanuts for about five years.

Are there benefits to using inoculants on shorter rotations?

As noted above if the history of inoculation indicates the nodulation is not achieved after a few years out of peanuts then inoculation is called for. If growers are unsure about whether to inoculate many prefer to err on side of inoculating rather than risk not having a nodule load. In the latter case expensive fertilizer applications may be required to help the producer fulfill yield potential.

How should farmers handle/store inoculants?

Before we apply inoculants give yourself the best shot at effective application. Don't rely on expired inoculant (check the expiration date), keep the inoculant out of direct sunlight and heat (less than 90 F), and don't use an inoculant without assurances that it has been cared for. Think a dealer might be storing product in a hot warehouse? Then get your inoculant somewhere else. And don't use an inoculant if the packaging looks beat up or there is slime floating in a liquid inoculant. Another farmer might not have used all of their inoculant and returned it to the dealer! The small volume of inoculant in small

pouches for seedbox application is particularly vulnerable to heat. I have seen these pouches sitting on the dash of a pickup! I remind growers that *Rhizobium* inoculant is live bacterium! It is not a bag of fertilizer. We have to take care of it.

What are recommendations for properly applying inoculants?

First, growers should check their planter equipment. I have used planters with granular drop hoses, which were plugged with spider webs and dirt. In another case a rock or something must have hit the liquid spray nozzle as it was shooting inoculant off to the side. Make sure the granular drop tubes or spray nozzles shoot the inoculant into the seed furrow around the seed. If the tube or nozzle is shooting at the furrow from more than 6 inches away then dilution of inoculant around the seed occurs. I fixed one planter by using a short piece of tube and duct tape to extend the end closer to the seed furrow by about 6 inches.

Many growers have never checked granular or liquid volume delivery to the seed furrow. It is not difficult to determine liquid rates using your tank volume as a rough guide. Granular inoculation is harder to gauge and requires some work using a graduated cylinder. The goal is to tag any rows that are putting out too little inoculant. As a habit check the nozzles occasionally or rotate the drive tire to ensure inoculant is coming out.

In many peanut soils where soil moisture is minimal and growers may rely on irrigation to germinate the seed, shallow planting depth can reduce *Rhizobium* viability if the soil becomes hot for a couple of days. Soil temperatures in sandy soil on peanut seed at ½ to ¾" depth can exceed 120 F, thus reducing microbial numbers substantially even though they are in the millions. Texas South Plains suggestions include switching to granular inoculants if the soil is or may become very dry.

Occasionally, growers may also apply starter nitrogen to peanut. I have observed N levels as low as 30 lbs. N per acre reducing *Rhizobium* nodulation, particularly for N placed close to the seed.

Finally, some farmers ask, "Can I use my soybean or other inoculant for peanuts?" Only if you want to waste your money! The inoculant companies have carefully selected *Rhizobium* strains that are specific for a particular legume. Always be sure to use an inoculant specific to your crop.

What are the advantages/disadvantages of the different forms (powder, liquid, frozen)?

I believe that when granular and liquid inoculants are available there are few if any advantages to powder or seedbox inoculants—provided you have the planter equipment to apply them. In other crops besides peanut, the "advantage" of powder inoculants is if there are no granular or liquid inoculants available. Most planters at least have the capability to put out granular inoculant of some sort. My experience is that in many soil types, powder inoculants are not as desirable and do not perform as well as granular and liquid inoculants. This is in part because powder inoculants are most susceptible to handling mistakes or desiccation on the seed before planting. Furthermore, powder inoculants without a sticker do not adhere to the seed thus to use them correctly the seed must be wetted with water, Coke, etc. then mixed. This is impractical for peanuts due to the large volume of seed. If you must use a powder inoculant, your best option is to choose one with a sticker already included. Without a sticker then expect that air/vacuum planters will blow much of the inoculant off.

As we move from powder to granular to liquid inoculants we substantially increase the numbers of *Rhizobium* delivered to the seed. I don't think there is a big need to change your current planter if you can only apply granular inoculant. Granular inoculants may offer some advantage in adverse soils, particularly under desiccating conditions, as the granule affords some protection to the *Rhizobium*.

The newer frozen inoculants are delivered to the grower then stored in a freezer until use. This concept offers additional protection from mishandling of inoculant prior to planting, but when following application instructions there is not necessarily an increase in the numbers of *Rhizobium* delivered to the seed. If growers can use either granular or liquid inoculant, use the one easy for you and your planter.

Calculating the cost of inoculant per billion *Rhizobium* is one way to evaluate product expenses, but the differences probably don't merit making changes in your existing planter.

Some farmers double their inoculant rate. Is this advisable?

Unless there is a compelling reason to increase inoculation rates because of adverse soils (very sandy, low or high pH) or poor planting conditions, growers cannot normally expect an increase in yields. Double rates are often used as insurance against inoculant failures. If growers choose to increase inoculant rates, for liquids I suggest they use two products from different companies or perhaps even better, combine liquid and granular applications to accommodate possible limitations due to environmental conditions.

Are inoculants affected by fungicides?

Some fungicides and other chemicals such as micronutrient mixes that are applied in solution with the inoculant may be incompatible with the inoculant. Check with your inoculant dealer for company recommendations on chemicals to avoid. The dealer himself may have to contact his company's research department if he doesn't have the information on hand.

Should farmers avoid chlorinated water if using liquid inoculants?

Yes. Because there are billions and billions of *Rhizobium* cells in the inoculant, chlorination at the level found in municipal water supplies would not quickly kill off so many *Rhizobium*. If a farmer used chlorinated water, however, than let his planter sit overnight, I would expect some decline in the numbers hence viability of the inoculant.

How can farmers check nodulation effectiveness and activity?

Timely evaluation of *Rhizobium* nodulation on peanuts or any inoculated legume crop should be part of a comprehensive crop scouting program. Effective *Rhizobium* inoculation and nodulation for peanuts is essential to approach yield potential. Because of adverse soil conditions in West Texas, successful nodulation for peanuts is expected but not guaranteed. In fact, general observations suggest that 20 to 25% of peanut fields in the Texas South Plains are undernodulated. Poor nodulation appears to be somewhat correlated with caliche soils, where pH > 8.0 may curtail *Rhizobium* effectiveness. Discovering poorly nodulated fields early in the season allows time for implementing or adjusting an N fertilizer program to compensate for loss of fixed N to the peanut.

A good time to evaluate *Rhizobium* nodulation on peanut fields is when most stands have been in the ground 4 to 5 weeks. Plugged drop tubes on granular inoculant or plugged nozzles for liquid inoculant will often be evident as peanuts yellow even if N was applied. In a couple areas of the field use a shovel to dig (don't pull) plants to evaluate nodulation. If desired, swirl roots in a bucket of water to remove soil. Nodule mass is more important than number of nodules. Slice open several nodules. Active nodules are pink to dark red inside. If nodules are white inside they are not yet active so check again in another week for **pink or reddish color**. (Later season, older, inactive nodules will be gray or greenish inside.) If nodulation is poor there is no effective means to improve it.

If no nodulation or poor nodulation is observed check the field again in ten days just to be sure. If poor nodulation persists, consider a modest N fertilizer program to address the crop N requirement. Also,

to possibly pinpoint why that field may not have nodulated, ask yourself if any of the above mistakes may have occurred.