BENEFITS OF SOYBEAN NODULATION

Nodulation Development

The process of nodule development and nitrogen (N) fixation begins with 'communication' between soybean roots and *Bradyrhizobia japonicum*. Bacteria recognize compounds from the root hair and express 'nod factors' (lipochitooligosaccharides) in return. This expression causes root hair modification and allows *B. japonicum* to enter root hairs where they multiply rapidly. Once formed, nodules can capture atmospheric N and convert it to ammonia (NH_3). Soil factors influencing *B. japonicum* survival include pH, temperature, texture, water content, and soil-available nitrogen.

Value of Nitrogen Fixation

There is great value to this bacterial relationship as soybeans in the pod fill stage can fix nitrogen at a rate of three pounds of N per acre per day.[1] Farmers should scout roots to determine the onset of nodulation and nitrogen fixation. In good conditions, five to seven nodules have developed on taproots two weeks after emergence.

Figure 1. Nodules with pink interiors are fixing nitrogen. Photo courtesy Richard Taylor and Shawn Tingle, University of Delaware.

Inoculation is a practice used on fields where nodulation is minimal, and where nitrogen fixation appears to be lagging with plants not 'greening up'. Nitrogen fertilizers are not efficient N suppliers to soybean plants, and soil-available N deters nitrogen fixation. Inoculants are relatively inexpensive and do not lower yields. Soybean production now focuses on profitability and closely measures the value of inputs and the effect on yield.

Re-Inoculation

A positive yield response from inoculation is expected for first-time soybean fields and those soil environments not supportive of long-term bacteria survival. Soybean producers in the north and east have experienced consistent positive yield responses to re-inoculation. Even in the Midwest, fields with soybeans for the first-time or fields in a three-year or greater rotation away from soybean are expected to have a positive yield response to inoculation.[1] Certain field conditions hinder *B. japonicum* survival and re-inoculation of soybean fields is recommended when more than one of the following soil conditions are present in a field:

1. Soil pH is below 6.0. Greater response from inoculants can be expected in fields with a pH below 6.0.
2. Fields that have been flooded for several days can create anaerobic conditions for the rhizobia.
3. Compaction and cool soil temperatures, due to no-till practices, can reduce nodulation.
4. Fields with sandy soils and low organic matter (less than 1%) should be re-inoculated every year.[1,2] These soils generally have very low populations of rhizobia bacteria.

Figure 2. Poor nodule development below ground. The plants displayed yellow above-ground foliage. Photo courtesy David Holshouser, Virginia Cooperative Extension.

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Yield Response

Yield responses to inoculation vary from year to year and field to field. *B. japonicum* is not native to soils in North America. The success of *B. japonicum* populations depends on rate of multiplication and ability to infect root hairs. Some positive yield response scenarios across North America are listed:

- Typical yield increases are 1 to 10 bu/acre.[3]
- Yield improvements of 1 to 2 bu/acre have been reported on fields with a previous inoculation application.[4]
- A yield improvement of 49 bu/acre has been reported on land with no history of soybeans.[5]

Double Inoculation

Commercial inoculation has a target of 100,000 bacteria per seed at the time of seeding. Bacteria numbers are expected to multiply five to eight times during ideal conditions in the first few weeks of seeding.[6] Effective N fixation uses millions of bacteria, and double inoculation can be beneficial in fields where soil conditions are not ideal and soybeans are being planted for the first time. More common in the northern United States and Canada, double inoculation applies inoculant to seed twice and helps plants form nodules at an optimal rate and time. Stacking inoculation products is another practice that can increase nodulation early in the season. With stacked inoculation, a liquid or granular inoculant product is applied to the soil or seed furrow in addition to a seed-applied inoculant.

Summary

The value of nitrogen fixation and supply comes almost solely from the relationship between *B. japonicum* and soybean root hairs. Take the opportunity to enhance this relationship with inoculation at planting time.

Sources:

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[3] Abendroth, L.J., Elmore, R.W., and Ferguson, R.B. 2006. G06-1622 Soybean inoculation: applying the facts to your fields. University of Nebraska-Lincoln.

[4] Staton, M. 2012. Is soybean inoculation profitable? Michigan State University. https://www.canr.msu.edu/.

[5] Mueller, N., Elmore, R., Daugherty, R.B., and Shapiro, C. 2015. Soybean inoculation: when, where, and why. University of Nebraska-Lincoln. https://cropwatch.unl.edu/.

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