Factors Affecting Soybean Nodulation

Key Points:

- The process of nodulation requires that the bacteria, *Bradyrhizobium japonicum*, and the soybean form a mutually beneficial or "symbiotic" partnership.
- Rhizobia growth, health, and activity depend on the initial population of bacteria and soil conditions that can favor or hinder their development
- Reduced nodulation can lead to nitrogen deficiency symptoms in soybeans if residual nitrogen is not available.

Healthy nodules on soybean root.

Biology of Soybean Nodulation

- Soybean nodulation is initiated in the early vegetative stages, within 2-4 weeks of germination, and usually begins Nitrogen fixation around V2.
- The process of nodulation requires that the bacteria, *Bradyrhizobium japonicum*, and the soybean form a mutually beneficial or "symbiotic" partnership.
- The bacteria adhere to the roots and create a chemical bond, forming root tissue (nodules) around the bacteria.
- The bacteria reside in these root nodules, where they use a nitrogenase enzyme to convert atmospheric nitrogen (N_2) to ammonium (NH_4^+), a form of nitrogen available to the plant. The plant provides photosynthates or sugars to feed the bacteria in return.
- For this relationship to develop, rhizobia bacteria must be present in the root initiation area.

Factors That Affect Rhizobia Health

Rhizobia growth, health, and activity depend on the initial population of bacteria and soil conditions that can favor or hinder their development. Several factors can reduce activity of these bacteria:

- Oxygen-limiting environments, like fully saturated soils, can reduce rhizobia activity. The bacteria are living organisms and require ample oxygen availability to be active.
- Soil pH can also affect the nitrogen production and health of the bacteria, as it does the soybeans. Soil pH < 5.6 or >8.0 creates a difficult environment for the bacteria to function efficiently.
- Survival in soils with low organic matter can be reduced due to insufficient food sources for the bacteria to live on until they adhere to the developing root hairs.
- Activity and health of bacteria can deteriorate in storage as well. Be sure the rhizobia inoculant and treated seed is stored in a cool, dry area, preferably below 77°F (25°C), to avoid heat or water damage.
- Nitrogen fixation is sensitive to soil drying. Dry conditions can lead to excess sodium in the root zone, restricting water availability to the bacteria. Use caution when applying talc seed amendments that can dry seed as well as the bacteria in the inoculant.
- Soil temperatures in the range of 40-80°F (4-27°C) are optimum for survival of rhizobia bacteria.
- Some fertilizers applied with the seed or in-furrow can be toxic to the rhizobia bacteria.
- Nitrogen availability in the soil will also reduce the soybean-to-bacteria relationship. The plant may not initially need the bacteria due to excess residual nitrogen in the soil. In such cases the soybean plant will not recognize the bacteria chemical reaction, and thus will not initiate nodular tissue formation.

Soybean field not previously planted to soybeans.
Dark green strips were inoculated with rhizobia.

Symptoms of Reduced Nodulation

Reduced nodulation can lead to nitrogen deficiency symptoms in soybeans if residual nitrogen is not available.

- Yellow and stunted soybeans will be evident in those situations.
- The areas of yellowing may vary based on the soil conditions and issues noted on the previous page.
- Soybean fields with excessive moisture early in the season may have more extensive yellowing.
- Soil compaction limits rooting and root hair development. Chemical signals from the roots that invite the bacteria to colonize can be reduced with limited rooting.

Field not previously planted to soybeans shows symptoms of nitrogen deficiency.

Other Field-Specific Issues May Lead to Yellowing

Yellowing is not always due to reduced nodulation. Other possible causes of soybean yellowing include:

- Soybean cyst nematode activity will lead to yellow, stunted soybeans.
- Other nutrient deficiencies may appear similar to nitrogen deficiency. Iron chlorosis due to high soil pH may be able to be corrected using an EDDHA iron chelate in-furrow or foliar treatment.
- Herbicide applications can yellow leaves and in some cases, stunt plants.
- General environmental factors such as drought, compaction, soil pH conditions, and excessive rainfall may lead to yellowing.

Management Information

- Check first year soybean fields for nodulation around V2 to V3. Adequate nodulation is 7 to 14 nodules per plant.
- If less than 5 nodules are present, wait about a week and take another assessment.
- The number of nodules formed on the roots along with the amount of nitrogen fixed continues to increase until the R5 stage of crop development.
- Nodules that are fixing nitrogen are pink or red inside. Green, brown, or white indicates that little or no fixation is occurring.
- If the number and quality of the nodules is not sufficient, supplemental N can be applied.
- Applications of a nitrogen source at less than 44 pounds of actual N per acre can be made.
- Avoid 28% solution as a broadcast application.
- Follow best management practices if using urea-type products; apply at early flowering, when foliage is dry.
- Leaf burn or “shot-holes” from the applications may occur.
- Higher rates of N can be applied but are usually not profitable.

Field areas show N deficiency due to poor nodulation.

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