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# Nodulation in Soybeans — Exactly what is it? How do I know if it is happening in my field?

**By Doug Alderman,** *CCA-ON*

Nodulation is defined as a soil bacteria's (*Bradyrhizobium japonicum*) ability to penetrate and fix nitrogen with the soybean roots. All legumes have the ability to do this, however the strain of bacteria is quite different for each crop.

For nitrogen fixation to occur, nitrogen-fixing bacteria in the species of *Rhizobium* need to be present in the soil. If soils do not already contain a high population of *Rhizobium*, these bacteria can be added either as liquid or granular peat inoculants or as a peat-based powder. Fields never planted to soybean or fields with sandy soils (low organic matter soils) need to be inoculated every year. No-till and earlier planting situations, soil compaction and cool soil temperatures put stress on the legume seedling, which in turn can reduce nodulation.

## Nodulation begins early in the soybean plant's life, but fixation of nitrogen does not start until the first or second trifoliate

At this stage, under good conditions, a well nodulated soybean plant should have five to seven nodules on the tap root and increase to 12 nodules per inch of tap root at flowering (R1). The amount of nitrogen fixed by the plant will increase with the number of nodules. The number of nodules on the root will increase through to seed formation in the upper pods of the soybean plant. Healthy nodules have a pink or red color inside and are actively fixing nitrogen. The reddish color is called the leghemoglobin (think of hemoglobin in blood) that supplies oxygen to the bacteria in the nodule. A greenish brown or white color indicates that the fixation is not taking place or it is just beginning. To check the nodules, carefully dig out plants with a small shovel and rinse the plant in water – otherwise you may break them off by pulling the plant out of the ground.

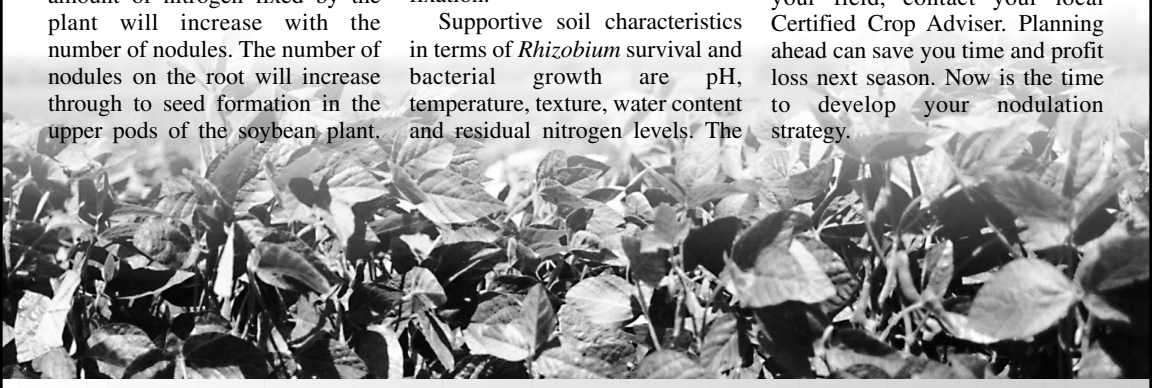
## Once nodules form, they can capture atmospheric nitrogen ($N_2$) and convert it to ammonia ($NH_3$)

Ammonia, in turn, is converted by the nodule to a form of nitrogen used by the plant called ureides. In this case the soybean plant supplies carbohydrates to the bacteria and they in turn fix nitrogen for the soybean plant. This is often referred to as a symbiotic relationship. Although *Bradyrhizobium japonicum (Rhizobium)* are efficient producers of nitrogen, the soybean still acts as a host and is depleted of energy resources by the bacteria. *Rhizobium* bacteria have the ability to compensate for the nitrogen demands of the plant by increasing or decreasing nitrogen fixation.

Supportive soil characteristics in terms of *Rhizobium* survival and bacterial growth are pH, temperature, texture, water content and residual nitrogen levels. The optimal soil pH is between six and seven. Extremely acidic or alkaline soils may reduce nodulation by as much as 40%. Most favorable root temperatures for nitrogen fixation and soybean growth range from 23° to 28°C. In this temperature range, the bacteria will begin actively fixing nitrogen within seven to ten days of forming nodules. When soils are cooler than this, both nodule formation and nitrogen fixation may be delayed. Extremely sandy soil (95% sand) reduces the survivorship of multiple bacteria species including *Rhizobium* populations when compared to soils with a clay mix. Lower soil water-holding capacity and wider fluctuations in soil moisture may be the primary factors reducing bacterial populations in sandy soils. Residual nitrogen in the soil also plays a significant role in the amount of nodules formed as well as the amount of nitrogen fixed throughout the season. If soil residual nitrogen is high, we would not expect to see as many nodules on the roots as in a soil with deficient or normal nitrogen levels.

## Pay attention to nodulation in your fields this year

If you have questions or concerns about the nodulation in your field, contact your local Certified Crop Adviser. Planning ahead can save you time and profit loss next season. Now is the time to develop your nodulation strategy.



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