Soybean Nutrient Profile

Nitrogen

This nitrogen profile is the fourth of a 13 part weekly series dedicated to the function of the essential nutrients in soybean. After excluding carbon, hydrogen, and oxygen, we are left with a 13 part series in which we will explore how nutrients are used throughout the plant as well as how to identify deficiency symptoms and develop nutrient management decisions.

In the Plant

Nitrogen (N) accounts for the greatest concentration of all mineral elements found in plants ranging from 1% to 6% N by weight. However, in the minds of many, N use in soybean often takes a back seat to many of the other essential nutrients due to the presence of biological N-fixation in legume crops. Producers will often check for active nodulation in young soybeans (the presence of which typically indicates an adequate supply of N) and then forget about N for the remainder of the season.

Nitrogen fixation, the act of converting atmospheric N (N_2) into the plant usable form of ammonium (NH_4^+), is economically essential to soybean production as soybeans utilize up to 5 lbs of N bu^{-1} A^{-1}. This means that a 50 bu A^{-1} yielding crop would require up to 250 lbs of actual N. Nitrogen fixation occurs when a bacteria (*Bradyrhizobium japonicum*) infects soybean root hairs around which the soybean will develop a nodule (figure 1). Inside the nodule, the plant will supply energy in the form of sugars, carbohydrates, and adenosine triphosphate (ATP - discussed in a previous profile on Phosphorus) as needed for the fixation process. In return, the plant receives NH_4^+ from the bacteria. This process can account for up to 80% of the N required by the plant.

Once in the plant, N is a constituent of many plant cell components, including chlorophyll and other proteins and amino acids. The presence of adequate N is necessary for optimum photosynthetic activity and vegetative growth. Excess N, however, can lead to a reduction in uptake of phosphorus, potassium, and sulfur and can delay maturity in many crops.

In the Soil

Plants can utilize two forms of N from the soil, nitrate (NO_3^-) and NH_4^+. The presence of either of these sources depend on a variety of factors including pH and soil moisture, although NO_3^- is typically found at greater concentrations in most environments. Nitrogen is ever changing in the soil, especially in the southern regions of the United States, and has a high potential to be lost due to leaching of NO_3^-, fixation of NH_4^+ in clay minerals, immobilization by the decomposing of organic residues, or volatilization of ammonia (NH_3). For these reasons, soil N is rarely included in soil tests unless specifically requested and should be assumed that supplemental N is required for most crops annually.

Figure 1. *Active, nitrogen fixing nodules on soybean roots. Active nodules will have a pink to red color when cut open while non-active nodules will be green to brown. (North Dakota State University, 2014)*

Although a legume crop, such as soybean, can take up either NO_3^- or NH_4^+, the majority of utilized N will come from N fixation in the form of NH_4^+. The N fixing bacteria can either be found in the soil where a history of soybean production is present or can be supplied on the seed at planting through various commercial inoculants. Infection of the roots, nodulation, and subsequent N fixation can be affected by a myriad of factors including soil salinity, low pH, extreme cool or hot temperatures, and drought stress.

Deficiency Symptoms

Symptoms of N deficiency in soybean typically begin in older leaves as the available N is remobilized in the plant to young tissues. Symptoms include the appearance of light green to yellow foliage on older growth with progressing symptoms on new growth as the deficiency worsens. Nitrogen deficient soybean will have markedly reduced vegetative growth with fewer leaves ultimately resulting in reduced grain yield and quality.

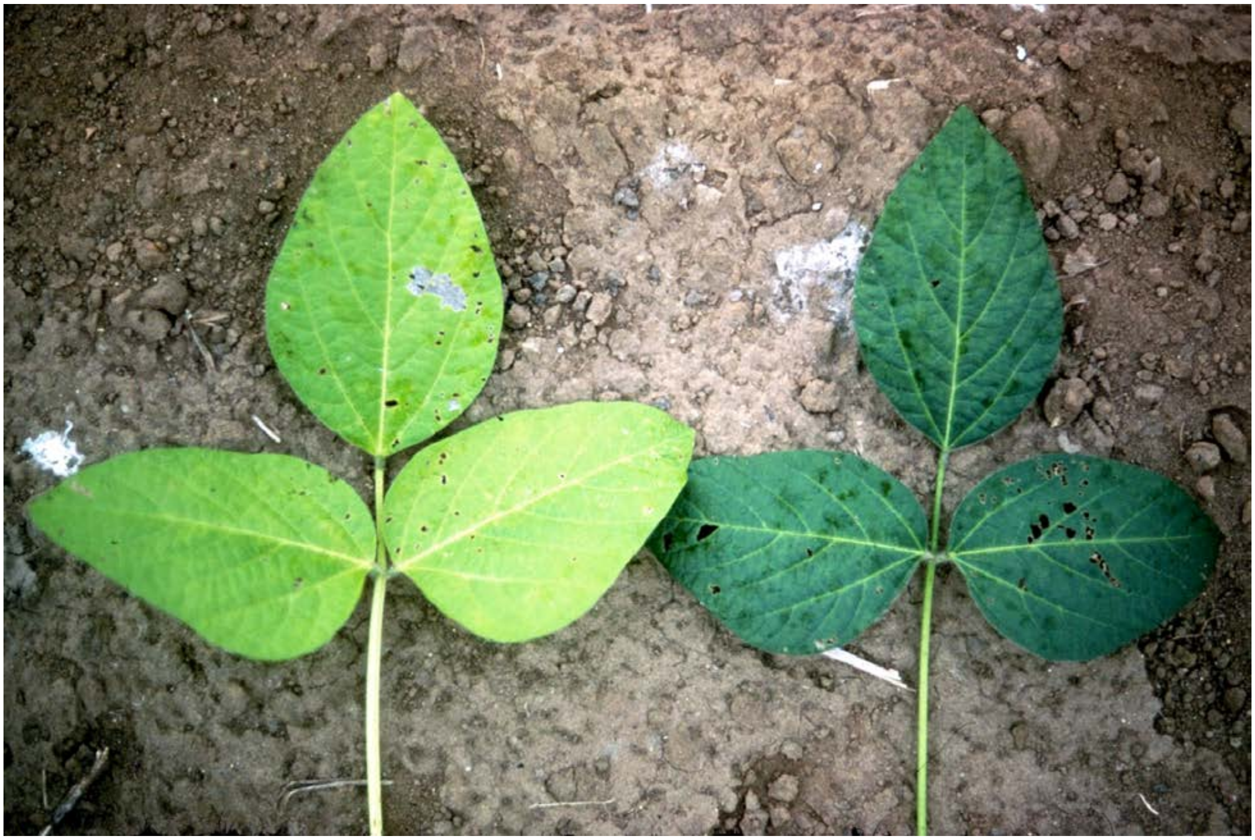

Figure 2. *Soybean nitrogen deficiency symptoms appear as chlorosis beginning on the older leaves. (IPNI, N.R. Usherwood, 2017)*

Deficiency Corrections

Because the majority of the plants N will come from N fixation, a deficiency may not always be directly stemming from a lack of N but, in some cases, a lack of nodulation. This is often a result of poor inoculation due to low pH, ineffective seed inoculation prior to planting, or poor environmental conditions at planting. Regardless of the underlying cause, supplemental N must now be provided to maintain the remaining yield potential. With the understanding that soybean requires up to 5 lbs of N bu^{-1} A^{-1}, producers must make a decision of how much N to provide based on the realistic yield potential of their individual field. If an N application is to be made due to poor nodulation, multiple applications will often be required throughout the growing season. Please reach out to your local county agent to help with these decisions on a field to field basis.

To ensure adequate inoculation and nodulation prior to the growing season, producers should consider the following situations when deciding on whether or not they need to inoculate the seed prior to planting. Molybdenum should always be added as a seed treatment when pH falls below 6.2 and a commercial inoculant is recommended in fields with a pH of 6.0 or less. Growers should include seed treatment inoculants in fields without a history of soybean in the previous two to three years or in environments that are not conducive to bacterial survival. In Louisiana, soybean grown in three year rotations with sugarcane or those in flooded rotations with rice and crawfish should utilize a commercial inoculant at each planting.

There are also conflicting opinions on the use of supplemental N and its effect on soybean yield. Research from the LSU AgCenter has shown that supplemental N does not consistently provide increased yield levels. Research has also shown that high levels of soil NO_3^- can reduce nodulation and N fixation. The concern is that fertilizer N at any amount greater than the small rates used in some starter fertilizers, can delay the development of active nodules beyond the amount of time in which the starter fertilizer is utilized, resulting in a reduction of plant available N in the interim.

To check for active nodules, begin scouting when plants have two to three fully unfurled trifoliates. Plants should be dug and not pulled out of the ground because nodules will easily be knocked off the plant. To remove excess soil, rinse the plants in water. Plants should have at least 5 to 10 nodules at this stage and at least 15 to 20 nodules just prior to R1 (first bloom). Nodules that are actively fixing N will be pink to red when cut open while those that are green to brown will not.

Takeaways

- Nitrogen (N) accounts for the greatest concentration of all mineral elements found in plants and is necessary for optimum photosynthetic activity and vegetative growth.
- Nitrogen is ever changing in the soil and has a high potential to be lost. Nitrogen fixation is necessary for adequate supplies in soybean and can be reduced by high soil salinity, low pH, extreme cool or hot temperatures, and drought stress.
- Nitrogen deficiency symptoms include chlorosis of older foliage with progressing symptoms on new growth as the deficiency worsens.

- Correction of N deficiency due to an inoculation failure should be discussed with your local agent to develop a season long plan. The realistic yield goal should be determined before deciding how much N should be applied.
- In Louisiana, soybean grown in three year rotations with sugarcane or those in flooded rotations with rice and crawfish should utilize a commercial inoculant at each planting.

References

Images: IPNI, N.R. Usherwood. 2018. IPNI Crop Nutrient Deficiency Image Collection. Version 2018-05-07.

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