SeedSCOOP

SOYBEAN FERTILITY DURING THE PLANNING SEASON

It has been a traditional practice to apply extra fertilizer prior to planting corn to sustain the following year's soybean crop. However, as soybean yields climb through genetic, biological, and crop protection advancements, it is increasingly important to analyze and maintain soil fertility to maximize soybean yield potential. This is not only due to increased soybean production but also increases in corn production, environmental concerns, and financial considerations.

Soybean Nutrient Requirements

As with any crop, nutrients are needed to sustain biological functions, help protect the plant from disease and other stresses, and ultimately create yield (Table 1).[1] Soybean plants require 16 elements for growth and seed development. Essential or macronutrients required by soybean include nitrogen (N), phosphorus (P), and potassium (K). Secondary and micronutrients that aid soybean growth include calcium (Ca), magnesium (Mg), iron (Fe), boron (B), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), chlorine (Cl), and sulfur (S). Soil pH levels for soybean should be maintained between 5.5 and 7.0 to help maintain overall soil nutrient availability; however, the optimal range is between 6.3 and 6.5. Figure 1 shows how pH, which is a measure of soil acidity or alkalinity, affects the availability of various elements.[2] Research has also shown that soybean cyst nematode (SCN) populations at harvest are likely to be higher when pH exceeds 6.5.[3]

Figure 1. Nutrient availability based on soil pH.
Illinois Agronomy Handbook. Permission granted for use by Dr. Emerson Nafziger, University of Illinois.

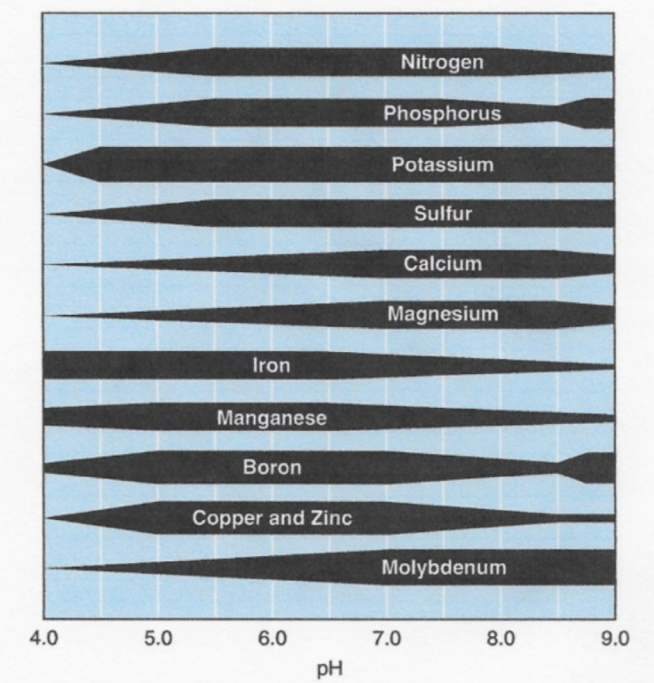

Table 1. Important elements and their function for soybean growth[1]

Element	Function within the plant
Nitrogen	Supports vegetative growth and is an essential component of proteins.
Phosphorus	Critical for root development, crop maturity, and seed production.
Potassium	Enzyme activator and helps the plant withstand extreme temperatures and drought.
Boron	Involved in sugar transport, cell division, and amino acid production.
Chlorine	Used in turgor regulation, resisting diseases, and photosynthesis.
Copper	Component of enzymes and photosynthesis activity.
Iron	Component of enzymes, essential for chlorophyll synthesis and photosynthesis.
Molybdenum	Nitrogen metabolism and fixation.
Manganese	Involved in chloroplast production, plant reactions, and activates enzymes.
Zinc	Component of enzymes and essential for plant hormone balance and auxin activity.

SOYBEAN FERTILITY DURING THE PLANNING SEASON

Applying extra fertilizer to corn ground for the next season's soybean crop may not supply the appropriate amount of nutrients for the soybean crop.
Each harvested soybean bushel removes about 4.02 lb of N, 0.4 lb of P, 1.25 lb of K, and 0.2 lb of S (Table 2). Since soybean plants produce N, P and K have the most potential to be deficient. Each bushel of corn removes less P (about 0.15 lb/bu) and K (about 0.21 lb/bu) than each soybean bushel; however, as corn yields climb, total nutrient needs increase and more respective nutrient pounds are removed.[4] This could potentially leave a soybean crop deficient of P and K. In recent years, 100 plus bu/acre soybean yields have been recorded making it necessary to be more aware of corn nutrient removals.

Table 2. Average pounds of essential nutrient removal per bushel of soybean harvested[a,5]

Soybean Yield	Nitrogen (4.20 lb/bu)	Phosphorus (0.4 lb/bu)	Potassium (1.25 lb/bu)
45 bu/acre	189	18	56.25
55 bu/acre	231	22	68.75
65 bu/acre	273	26	81.25
75 bu/acre	315	30	93.75

[a]Removal amount for each nutrient can vary depending on geographical location and growing conditions.

Environmentally, if "extra" P is applied for a current crop to fulfill the needs of a future crop, any loss from runoff or soil erosion from geographies in the Mississippi River drainage basin can ultimately feed the hypoxia issues in the Gulf of Mexico. Therefore, it is important to be environmentally responsible with P applications. Financially, dollars are lost when nutrients are lost to runoff or leaching, and budgets can be pinched when extra nutrients are applied to sustain another crop.

Deficiency symptoms may appear on soybean plants if any of the nutrients are limited. Generally, deficiencies and symptoms are rare unless stress from drought, compaction, prolonged saturation, root disease(s), soil insect feeding, pH imbalance, fertilizer burn, or chemical injury to roots cause symptoms to occur. Iron deficiency chlorosis (IDC) is a common deficiency appearing in high pH soils (above 7.0) and soils with high Na and Ca content. Symptoms of IDC include yellowing between the veins of the newest leaves and reduced nodulation and N fixation.

Seedling soybean plants may show P deficiency symptoms (stunting, smaller leaves, interveinal reddening or purpling on lower leaves) when soils are cool and wet, compaction restricts roots, or roots are injured by insects, fertilizer, or chemicals.

Because of the high demand for K in soybean, it can often be the most common deficiency. Potassium deficiency symptoms can occur in the early growth stages and can be confused with IDC. The contrast between the two is the chlorosis or yellowing of the leaf tissue is at the leaf margins with a K deficiency and with IDC, the yellowing is between the veins and under extreme conditions necrosis or browning of the interveinal area. Potassium deficiency symptoms can also become visible during the reproductive growth stages and while the reason for this is not entirely clear, it may be due to the amount of K translocated from the middle or upper leaves to the developing grain because of higher yields.[8]

Soil Nutrient Testing

The first step to determine the availability of soil nutrients is to collect soil samples for nutrient and agronomic testing. Ideally, a test should be conducted every two to three years and sampling should be completed near the same time of the season for consistency.[6] If maintenance fertilizer is not annually applied, soil testing should be completed every other year.[2] Soil tests should include an analysis for macro and micro nutrients, soil pH, buffer pH, organic matter, and cation exchange capacity (CEC).

Lime and pH

Based on the soil buffer pH test, lime, if needed, adds Ca and helps neutralize soil acidity. When soil pH is maintained between 5.5 and 7.0, a) nutrient availability is enhanced, b) microbial residue breakdown increases, and c) N fixation is maximized.[7] Lime dissolves slowly; therefore, applications should occur about 3 to 6 months before planting. Additionally, it should be applied one month or more before other nutrients are applied because lime can interfere with the availability of other nutrients, especially P. Lime sources should be evaluated as lime products differ in their neutralizing efficiency based on calcium carbonate equivalency and particle size.

SOYBEAN FERTILITY DURING THE PLANNING SEASON

Nitrogen

As a legume, soybean plants produce or fix N from the air into ammonia in their root nodules because of the presence of the rhizobia bacteria, *Bradyrhizobium japonicum*. Ammonia is a form of N that can be readily used by the soybean plant and is the primary N source for soybean. On average, about 55% of the required N is supplied by fixation. However, residual nitrate and mineralized N from soil organic matter are also utilized, particularly in the first three to four weeks after emergence because nodules are just forming. The soil must contain a healthy supply of the bacteria for nodules to form and produce N.

If a soybean crop has not been grown in a field within three to five years, been flooded, or the field has a course soil texture consideration should be given to inoculating the seed with living *B. japonicum*. Inoculated seed and inoculants are living organisms and should be handled and stored with care because they can be killed by desiccation, direct sunlight, heat, caustic fertilizers, and pesticides. If a field has high residual N, nodules may be slow forming because the plants are using the residual supply. In some cases, such as hot dry weather, the rhizobia may not colonize the soybean root and N may be limited, thus reducing yield. Additional N can be added if there are fewer than 7 nodules per plant, only nodules that are about 1/16 of an inch and are pink or red on the inside should be counted.

Research has shown that applying 60 to 70 pounds of actual N per acre can correct the N deficiency and provide an economic return, up to 10 bushels per acre, if applied timely. Ideally, the supplemental N should be applied between the R1 growth stage (one open flower on 50 percent of the plants) and the R2 growth stage.[9]

Foliar Applications

In nutrient-limited conditions such as sandy soils or in high yielding irrigated fields, macronutrient foliar applications at early vegetative growth stages may be beneficial and have increased yield by 15 to 20% in Iowa studies.[5] Some studies suggest soybean yield can be increased by foliar applying deficient nutrients between beginning seed (R5) and full seed (R6) growth stages.[5] However, many on-farm trials showed that foliar applications produced inconsistent results, and even decreased yield in some areas.[5] Foliar applications should be applied at low rates and during cooler day-time temperatures to help avoid damage to plant tissues.

Sources:

[1]Stowe, K.D. 2018. Soybean fertility basics. N. C. Field Report. North Carolina Producers Association. https://ncsoy.org/.

[2]Fernandez, F.G. and Hoeft, R.G. 2009. Managing soil pH and crop nutrients. Chapter 8. Illinois Agronomy Handbook. http://extension.cropsci.illinois.edu/.

[3]Staton, M. 2012. Managing soil pH for optimal soybean production. Michigan State University. https://www.canr.msu.edu/.

[4]IPNI Estimates of nutrient uptake and removal. International Plant Nutrition Institute. http://www.ipni.net/.

[5]Pedersen, P. 2007. Soybean nutrient requirements. Iowa State University Extension. https://crops.extension.iastate.edu/.

[6]Mengel, D.B. and Hawkins, S.E. Soil sampling for P, K, and lime recommendations. Agronomy Guide AY-281-W. Purdue University. https://www.extension.purdue.edu/.

[7]Wortmann, C.S., Krienke, B.T., Ferguson, R.B., and Maharjan, B. 2018. Fertilizer recommendations for soybean. NebGuide. Nebraska Extension. University of Nebraska. https://extensionpublications.unl.edu/.

[8]Mallarino, A. 2018. Soybean potassium deficiency symptoms during early and late growing stages. Iowa State University Extension. https://crops.extension.iastate.edu/.

[9]Staton, M. 2014. Identifying and responding to poor nodulation in soybeans. Michigan State University Extension. https://www.canr.msu.edu/.

Web sources verified 10/3/19.