Soybean Nutrient Profile

Phosphorus

This nutrient profile is a part of a weekly series dedicated to the function of the 16 essential nutrients in soybean. After excluding carbon, hydrogen, and oxygen, we are left with a thirteen 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.

We are approaching a momentous occasion as 2019 will mark the 350th anniversary of the discovery of phosphorus (P). The story of how Henning Brand, a 17th century alchemist, discovered what we now know as one of the essential plant nutrients in his basement is fascinating and well worth the read.

In the Plant

Phosphorus is a driver of plant growth and function because of its vital role in energy storage and transfer. Adenosine di- and triphosphates act as energy banks in plants. Energy is acquired during photosynthesis and the metabolism of carbohydrates and stored in these phosphate compounds for later use. When the phosphate ($H_2PO_4^-$) is split away from the ATP molecule the energy is released. This process of providing energy for plant functions through the splitting of $H_2PO_4^-$ from an ATP molecule is known as phosphorylation. When the ATP molecule is split, it reverts back to ADP. The addition or removal of $H_2PO_4^-$ and conversion between ADP and ATP occur readily in sufficient P environments.

Phosphorus is also essential in the formation of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). This genetic code is required for the production of proteins and compounds needed to develop both vegetative and reproductive structures. Phosphorus is also often associated with the root proliferation necessary for exploiting the maximum root zone available in our soils.

In the Soil

Dependent upon pH, a phrase that will be used often in this profile, plants will take up either $H_2PO_4^-$ or HPO_4^{2-} (orthophosphate). Phosphate, most commonly utilized in plants, is encountered by plants in the soil solution in pH ranges of 3-7.2, while HPO_4^{2-} is most often encountered in soils with pH greater than 7.2.

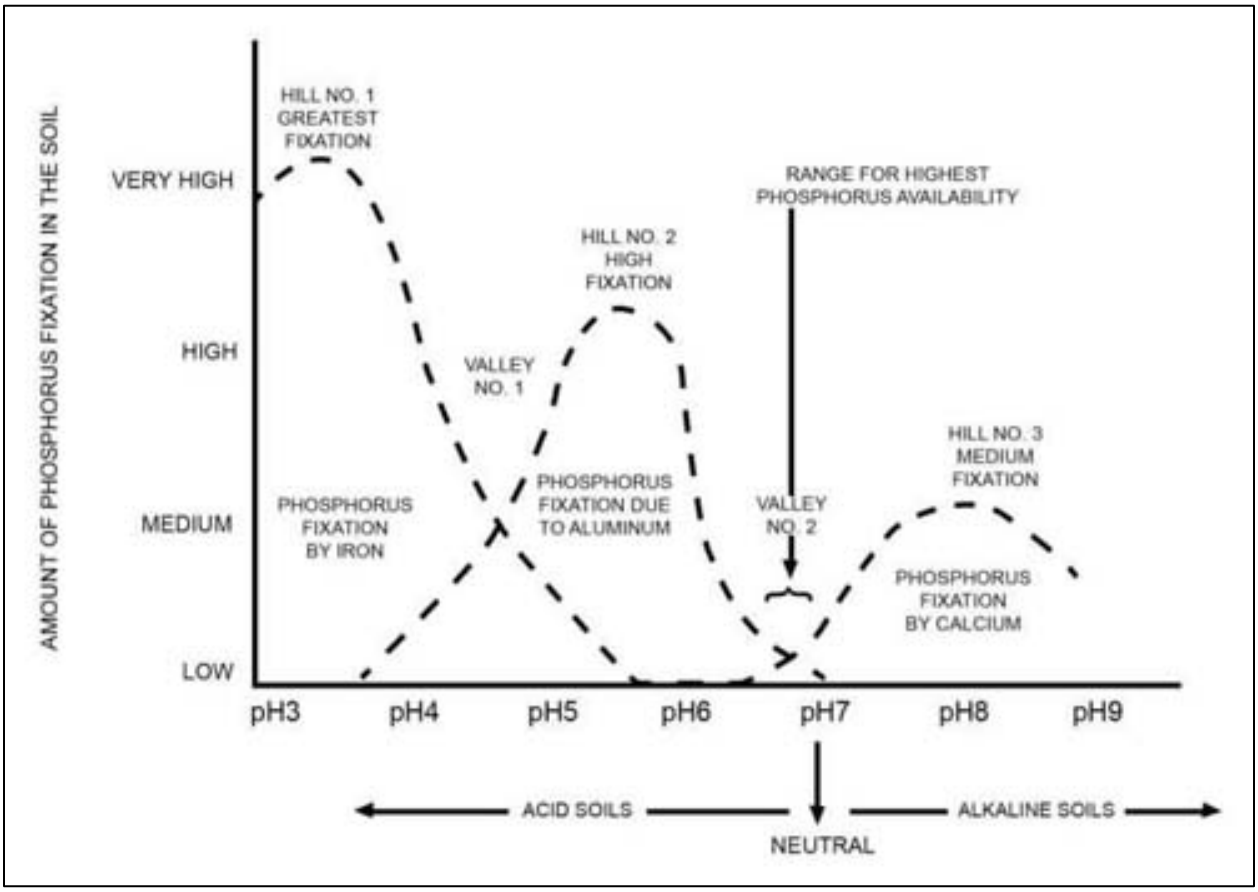

Figure 1. *The hills and valleys of phosphorus fixation give an idea of how pH affects the availability of phosphorus (adapted from M. Stewart, NRCS)*

Soil pH management, as it pertains to available P, is important for several reasons, the first being that HPO_4^{2-} (most prevalent at pH > 7.2) is taken up by plants at a much slower rate than $H_2PO_4^-$ (most prevalent at pH < 7.2). The second reason that managing soil pH is important for P availability is due to the fixation of P that occurs both at low and high pHs (figure 1). In soils with low pH, P precipitates or is adsorbed with iron and aluminum minerals. At high pHs,

P will precipitate or adsorb with calcium or magnesium minerals. Both instances can severely reduce plant available P.

Phosphorus moves through the soil at a very slow rate. The majority of the movement occurs through diffusion which is often slowed during cool, wet conditions that can be encountered early in the growing season. It is not uncommon for deficiency symptoms to appear in cool, saturated soils during the seedling stage. This is often not related to a lack of available P and is often corrected with increasing soil temperatures and drainage.

Figure 2. *Soybean phosphorus deficiency appear as stunted plants often times with dark green older leaves. (IPNI, L.A. Zanao, Jr., 2012)*

Deficiency Symptoms

Unfortunately for diagnostic purposes, P deficiency symptoms are not as striking as many of the other nutrients and can therefore be difficult to notice. Stunted plants, distorted leaf shape, and dark green to purple coloring of plant tissue are all visual symptoms of P deficiency (figure 2). Leaves will often appear cupped or more round than the typical leaf shape. Being mobile in the plant, similar to nitrogen and potassium, the older leaves will develop visual symptoms first. Phosphorus deficiencies will also often noticeably delay bloom appearance and maturity.

Deficiency Corrections

Because of the lack of mobility in the soil, P deficiencies are very difficult to correct during the growing season. Therefore the best correction for P deficiency symptoms is to develop and utilize an annual soil testing regimen prior to soybean planting as non-incorporated

applications only improve P soil test levels in the top 1 inch. Phosphorus applications should either be banded near the top of the row or incorporated to improve the distribution.

Takeaways

- Phosphorus is essential as the source of energy storage and transfer in the plant as well as a component of DNA and RNA.
- Phosphorus is greatly affected by pH and is most available to plants at a pH range of 6.0-7.2.
- Phosphorus symptoms appear as stunted plants with distorted and dark green to purple colored leaves.
- Correction of P deficiency symptoms are difficult during the growing season due to the immobility of P in the soil. Phosphorus applications should be made prior to the growing season based on soil test recommendations by either banding or incorporating the product.

References

Images: IPNI, L.A. Zanao, Jr. 2018. IPNI Crop Nutrient Deficiency Image Collection. Version 2018-05-07.

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