AGRONOMY

The Phosphorus Cycle

Phosphorus, nitrogen and potassium are the major elements required by plants. However, plants only need one-tenth as much phosphorus as they need nitrogen and potassium. Phosphorus is used by plants to form DNA, RNA and other vital compounds. It is used to store and transfer energy used for growth and reproduction.

Total soil phosphorus concentrations usually range from 200 to 5,000 ppm. These figures can be deceptive, however, because the available soil phosphorus may be only one percent or less of the total amount present. Think of an iceberg. All we see is the tip; more than 95 percent of it is below the water. So it is with phosphorus. Just as it is difficult to estimate the size of the iceberg by looking at the tip, it is difficult to estimate the amount of phosphorus reserves in the soil by just measuring extractable phosphorus (using the common extracts called Bray, Olsen or Mehlich).

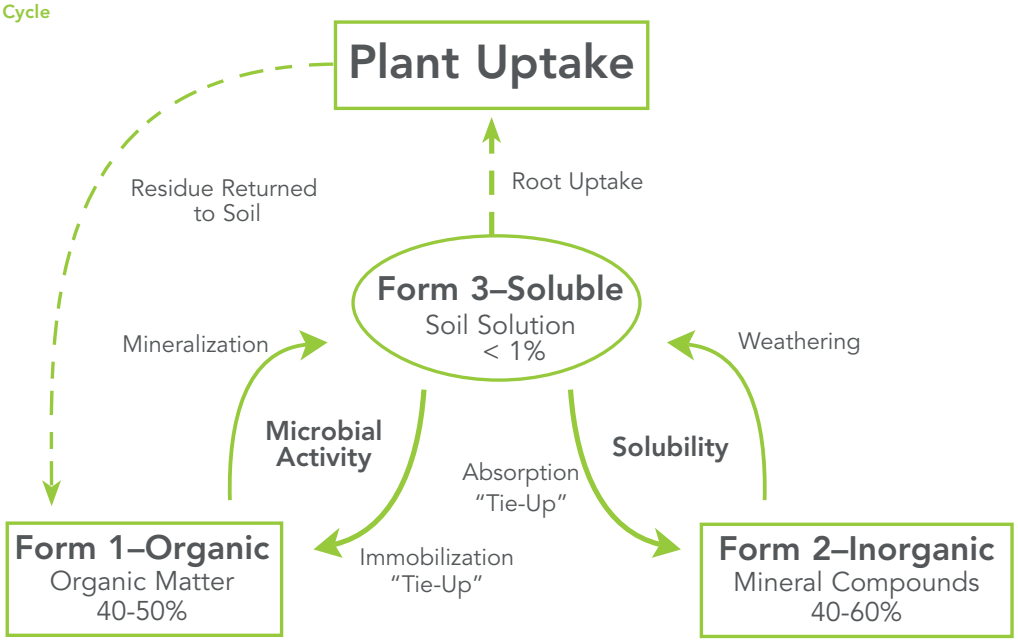
Though estimation is difficult, these reserves are very important. On the average, 70 to 90 percent of the phosphorus used by the crop comes from the phosphorus reserves in the soil while only 10 to 30 percent of the phosphorus fertilizer applied in a given year will be utilized by the crop. Therefore, even with an aggressive fertilizer program, the crop depends primarily upon preexisting phosphorus reserves for its phosphorus needs.

The Cycle

It is important to understand the phosphorus cycle and its role in making phosphorus reserves available to the crop (See Figure 1). Phosphorus exists in the soil in three different forms:

- Mineral phosphorus compounds that are inorganic
- Organic-matter phosphorus compounds
- Soil-solution phosphorus

Figure 1. The Phosphorus Cycle



Soil-solution phosphorus exists in equilibrium with soil organic matter and mineral forms. Equilibrium means phosphorus is being released from the organic and inorganic compounds (Forms 1 and 2) and removed from the solution (Form 3) simultaneously. This movement from soil solution to organic and inorganic forms is indicated by the solid arrows in **Figure 1.**

As a result of this equilibrium, phosphate anion concentrations in the soil solution are created. Phosphorus is absorbed by the plant directly from the soil solution. Thus, soil-solution phosphorus is actually the source of phosphorus for plants even though the bulk of the reserve is found in the soil organic matter and mineral forms. The concentration of the soil solution increases if there is more release than removal. Conversely, the concentration decreases if there is more removal than release.

Release and Removal

The release of phosphorus is generally due to weather, microbial activity and soil conditions. Specifically, we can break it down even further:

- Warm, moist weather conditions are responsible for increasing the rate that phosphate anions are released from minerals and low-solubility compounds like calcium, magnesium, iron and aluminum phosphates.
- The biological transformations occurring in the soil as microbial populations consume organic matter are responsible for the release and/or tie-up of soil phosphorus. These micro-organisms compete with plants to utilize the phosphate in solution and then release it again as the populations decline.
- The soil conditions that most influence release of phosphorus for plant uptake are soil pH, moisture content and aeration, soil temperature, organic matter content and the mineralogy of soil particles.

On the other hand, removal is almost solely related to the concentration of phosphorus in the soil solution. Plants absorb what is readily available. Thus, the equilibrium noted in **Figure 1** is the controlling factor in phosphorus absorption Plants can't absorb phosphorus if it is not present.

Phosphorus Turnover

Release and removal are key factors in phosphorus turnover. Concentrations of phosphorus in the soil solution are very low, frequently ranging from 0.01 to 0.06 ppm. In order to replenish the phosphorus concentration, the phosphorus in the reserves must
be released and simultaneously removed a number
of times. For example, during periods of rapid growth, phosphorus in the soil solution may be replaced ten times or more per day. That translates to 450 times during one growing season. Continual phosphorus turnover must happen for the plant to absorb the proper amount of phosphorus.

Conclusion

Crops depend primarily upon preexisting phosphorus reserves for their phosphorus needs. The two big reservoirs of soil phosphorus are phosphorus-containing minerals and soil organic matter. When phosphorus is released from these reserves, it goes into a soil-phosphorus solution where it is available for plant uptake.