COMMON GROUND
Harris Laboratory

Phosphorus in Turf Grasses

Like nitrogen and potassium, phosphorus is one of the major elements required by the soil. Phosphorus is used by the plants to form nucleic acids (DNA, RNA) and other vital compounds. Is also used in storage and energy transfer (ATP and ADP). Compared to nitrogen and potassium, plants only need one-tenth as much phosphorus. Phosphorus stimulates early season growth and root formation. Fertilization is required under the following situations: cool season growth, limited root growth and development, and fast growth production.

Symptoms of deficiencies in turf grasses include:

- Slow growth and/or stunted plants
- Purplish coloration of foliage
- Dark green coloration with browning of leaf tips
- Poor seed development (if growing for seed)

Typically, in turfgrass, deficiencies are described as a dark green color progressing to a purplish to reddish purple color, most apparent on the older leaves. Overall, stand appears as wilted and can be confused with the onset of drought stress.

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 just measuring extractable phosphorus (Bray or Olsen).

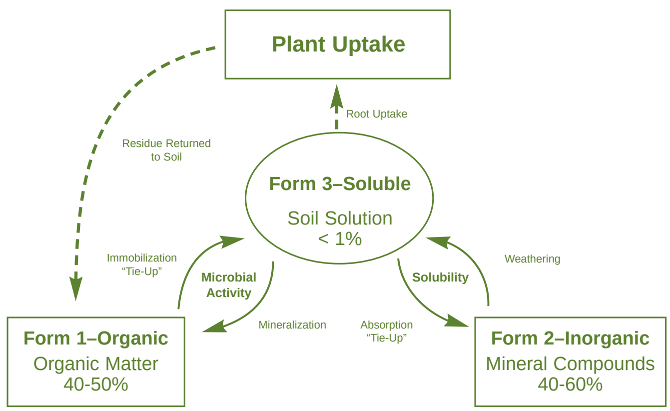
Though estimation is difficult, these reserves are very important. On the average, 70 to 90 percent of the phosphorus used by the plant comes from the phosphorus reserves in the soil while only 10 to 30 percent of the phosphorus fertilizer applied in a given year will be utilized by the turf. Therefore,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

Phosphorus Cycle

It is important to understand the phosphorus cycle in its role of making phosphorus reserves available (see the figure below). Phosphorus exits in the soil in three different forms:

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

Figure 1



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

As a result of the equilibrium, phosphate anion concentrations in the soil solutions are created. Phosphorus is absorbed by the plant directly from the soil solution, in the forms of H_2PO_4, HPO_4 or PO_4. 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 released than removed. Conversely, the concentration decreases if there is more removal than release.

The release of phosphorus is generally due to weather, microbial activity and soil conditions.

- Certain weather conditions are responsible for releasing phosphate anions from the low-solubility compounds (calcium, magnesium, iron and aluminum phosphates).
- Microbial activity is responsible for soil organic-matter release and/or tie-up of phosphorus.
- Various soil conditions influence the release of phosphorus from mineral and organic forms to the soil solution. These conditions include pH, temperature, moisture and amount of organic matter.

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 not absorb that which is not present.

Release and removal are key to phosphorus turnover. Concentrations 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 10 times or more per day. That translates to 450 times during one typical growing season. Continual phosphorus turnover must happen for the plant to absorb the proper amount of phosphorus.

Soil Phosphorus Reactions

As mentioned above, phosphorus is required by the plant to form vital compounds and to store and transfer energy for growth. However, soil minerals and organic matter react quickly with soluble phosphorus fertilizer to create compounds with very low solubility. Because soil compounds and conditions significantly affect the amount of phosphorus available, the ability to estimate soil phosphorus is crucial. Your challenge is to manage these reactions so that turf grasses have adequate supplies of available phosphorus.

Reactions with Soil Minerals

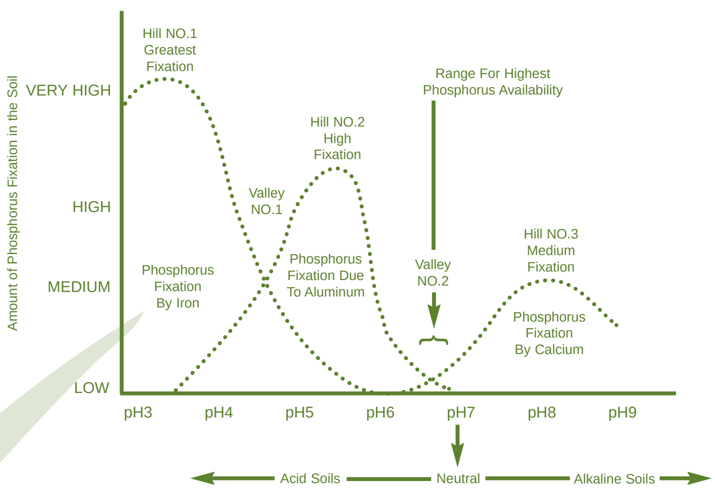
Availability of phosphorus is primarily dependent upon the pH of the soil. However, soil pH doesn't affect phosphorus directly. Instead, soil pH levels indicate how certain minerals (i.e., iron, aluminum, calcium) interact with phosphorus in the soil, and it is this interaction that affects phosphorus availability.

Most soils contain abundant quantities of iron, aluminum and calcium. Their presences and quantity are important because, in certain circumstances, each is capable of "fixing" the phosphorus, making it unavailable to uptake.

In alkaline soils, iron and aluminum minerals are nearly insoluble, while soluble calcium is abundant. In acid soils, iron and aluminum concentrations are high because the minerals are soluble, while calcium concentrations are low because the mineral has been dissolved and leached out of the soil. High concentrations of any of these minerals will result in the phosphorus being fixed in the soil and unavailable to the plant.

As you can see in Figure 2, there are hills and valleys of phosphorus fixation. The highest fixation occurs in acid soils due to high iron concentrations when the pH is less than 5.0. On the other end of the spectrum, alkaline soils also create phosphorus fixation problems due to high concentration of calcium.

Figure 2



When the soil pH is less than 5.0, iron and aluminum concentrations are very high and react quickly with phosphorus, creating iron or aluminum phosphate minerals. The best way to correct this problem is to correct the soil pH with limestone. Lime neutralizes the soil acidity and decreases the concentration of the iron and aluminum in the soil solution.

When the soil pH is greater than 7.0, calcium concentrations are high. Therefore, phosphorus fixation due to calcium is the problem. The obvious solution is to lower soil pH. Unfortunately, the amount of acid needed to neutralize many alkaline soils is difficult to predict. For example, a typical soil can contain anywhere from less than 1 percent up to over 5 percent lime. At 5 percent, the top three inches of soil would contain 25 tons of lime. It would require eight tons of elemental sulfur to neutralize the 25 tons of lime. These rates need to be applied prior to establishment. On established turf, you are limited as to the quantity that can be applied in any one application, no more than 5 pounds of elemental sulfur per 1000 square feet.

Phosphorus fixation occurs to some degree for all soils, even for pH levels from 6.0 to 7.0. This pH range is where phosphorus availability is at its greatest, because iron, aluminum and calcium are least soluble. At this range and in the very best of circumstances, turf grass may use 15 percent of a phosphorus top-dress application. When the soil is acidic or alkaline, fertilizer efficiency will decrease.

The best way to know if your soil has a high phosphorus fixation capacity is to monitor the rate at which the soil-test levels build when extra phosphorus fertilizer is applied. On the average, it requires nine pounds of P_2O_5 to raise the soil test one ppm for the Bray test. If your soil requires more, then this soil would have a high fixation rate.

Soil microbes require phosphorus as a part of their diet. As a result, microbes compete with plants for soil phosphorus. This is especially true if a residue with a high carbon to phosphorus ratio has been applied to the soil. In this case, the microbes will need extra phosphorus to help them decompose the residue. During decomposition, phosphorus is temporarily unavailable. The is called phosphorus immobilization. When decomposition nears completion, phosphorus will once again become available for plant uptake.