University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Phosphorus for Kentucky Turfgrasses

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Phosphorus (P) is an essential plant nutrient and a common component of many turfgrass nutrition programs. Although P application can improve turfgrass quality in some soils, most soils of Kentucky already have adequate plant-available P to support healthy turfgrass growth. What is the function of P within the plant, and how much P is required to sustain acceptable turfgrass in Kentucky? Also, if P applications are necessary, when and how should P be applied?

Function of Phosphorus in Turfgrasses

Phosphorus has many plant functions, but the most essential function is energy transfer. During photosynthesis, energy is stored in the high-energy compounds adenosine diphosphate or adenosine triphosphate (ADP and ATP). ADP and ATP may be transferred to other parts of the plant and then split, which releases a relatively large quantity of energy used for various metabolic processes. Essentially every metabolic process in turfgrass development requires P.

Phosphorus is absorbed by the plant as $H_2PO_4^-$ or HPO_4^{2-}. These forms of P are often referred to as orthophosphate or ortho-P. The former chemical species is more prevalent at low soil pH, and the latter is more prevalent at high soil pH. Small amounts of organic P may be absorbed by the plant, but the quantity and importance of organic P for turfgrasses is limited due to the instability of organic P compounds in the presence of active microbes. Phosphorus is highly mobile within the plant and P deficiencies normally appear on the most mature leaves first.

Phosphorus is associated with increased root growth, particularly during the early stages of development. During these early stages, turfgrass has a high demand for energy and often insufficient root growth to take up P. Thus, applications of P during turfgrass establishment increase root production and subsequently turfgrass establishment. Special care should be given to the N:P ratio during putting green establishment. A ratio of 5:2 has been shown to increase establishment compared to a 1:0 N:P, whereas further increases of P above a 5:2 N:P may actually decrease establishment.

Phosphorus deficiency in turfgrasses is uncommon in Kentucky but can occur in turfgrasses grown on some western Kentucky soils or on golf course putting greens. Western Kentucky from Nelson to Livingston counties has soils that naturally contain low concentrations of plant available P (Figure 1). Turfgrass grown on sand-based putting greens may also exhibit P deficiency because P is poorly retained in sand-based rootzones. Phosphorus-deficient turfgrass can appear different from other nutrient deficiencies and may actually appear darker green, particularly on the older leaves. When darker green leaves are observed in conjunction with reduced growth, P deficiency may be the cause. The darker green leaves are a result of an increased concentration of chlorophyll partly due to the reduction in growth. If P deficiency progresses, older leaves may appear purple, which is a result of excess anthocyanins, a pigment normally associated with ripening of some fruits, including blueberries.

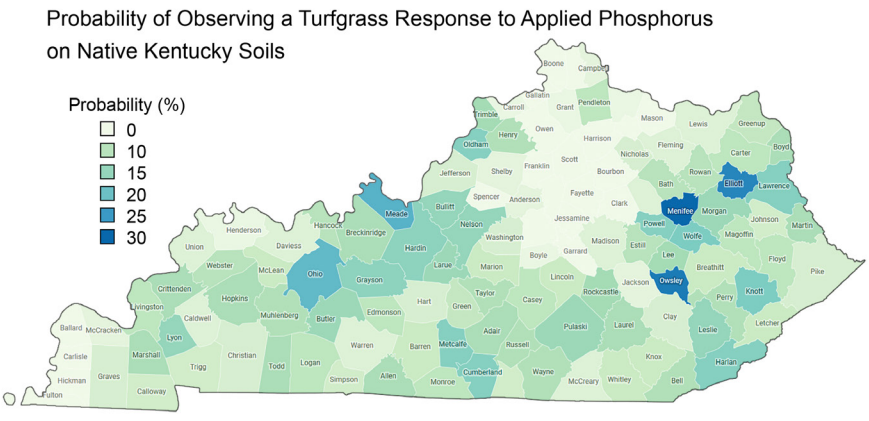

Figure 1. Probability of turfgrass responding to applied phosphorus on Kentucky soils

Tissue Testing for Phosphorus

Turfgrass tissue testing is not a dependable tool to inform P fertilization because baseline P concentrations in turfgrass fluctuate and are not well understood. Current research indicates that the P concentration in healthy turfgrass naturally fluctuates based upon turfgrass species, location, and even season. Tissue tests may be useful if tissue is collected from the same location at the same time of year and records are collected for several years. Fluctuations in tissue P above or below historical norms may provide useful information when diagnosing potential problems, but the decision to apply or not apply P based upon a single turfgrass tissue test is not a best management practice (BMP).

Soil Phosphorus

Most Kentucky soils contain an adequate supply of P to sustain acceptable turfgrass quality. Soluble P is highest in the soil solution when the pH is between 5.0 and 7.2, with maximum P solubility

occurring at a soil pH of 6.5 (Figure 2). Below 5.0, P precipitates with iron (Fe) or aluminum (Al) and falls out of the soil solution. Above 7.2, P may bind with Ca and become unavailable for plant uptake. Phosphorus in these secondary minerals of Fe, Al, and Ca may again become plant available through dissolution if the soil pH remains between 5.0 and 7.2. This relationship between pH and P availability is one reason that soil pH is a critical part of soil testing for turfgrasses.

Soil organic matter contains between 1% and 3% P. The majority of P in organic matter is organic P, although a small fraction is already in the ortho-P (plant available) form. Organic P must be mineralized into ortho-P by soil microbes in order for the P to become plant available. After mineralization, the P is in an inorganic form and may be taken up by the turfgrass or returned to its original organic form via immobilization by other soil microbes. Mineralization and immobilization are soil process mediated by soil microbes, and thus environmental variables (such as pH, soil moisture, soil temperature, etc.) that influence soil microbial activity will influence P mineralization and immobilization.

Soil Testing for Phosphorus

Phosphorus soil tests are very important for agricultural crops. However, for Kentucky turfgrasses, soil testing for phosphorus has limited use because P levels have not been calibrated to a turfgrass response; applying specific amounts of P to turfgrasses based upon soil P concentration has been proven unreliable. For turfgrasses, P soil tests are best used to indicate when P should *not* be applied. Current research on both warm-season and cool-season turfgrasses indicates that turfgrasses grown on soils with a Mehlich III P concentration ≥ 10 ppm will not likely respond to applied P. Approximately 80% of Kentucky turfgrass soil tests report soil P concentrations ≥ 10 ppm, indicating that the majority of Kentucky soils do not require additional P to sustain acceptable turfgrass. Determining soil P concentrations by county provides a more precise indication whether P is necessary in your location (Figure 1). At best, turfgrass grown in Menifee and Owsley counties have a 30% probability of responding to applied P, whereas the majority of counties have less than a 20% probability, and many counties have less than a 1% probability of responding to applied P. To save money and reduce environmental risk, P can be omitted from nutrient applications to turfgrass until a soil test indicates the Mehlich III P concentration is less than 10 ppm *and* the turfgrass appears unacceptable.

Applying Phosphorus

If your turfgrass appears acceptable to you, then additional P is normally not necessary regardless of soil test P values. However, if your turfgrass is not acceptable *and* a soil test confirms the soil concentration is less than 10 ppm Mehlich III P, then additional P may be warranted.

When applying P to turfgrass, perhaps the easiest and most common method is to use a fertilizer that contains both N and P and apply the fertilizer during your next scheduled N application. Once the turfgrass grows out of the P deficiency, P may be lowered or eliminated from future applications. Simply applying P 'just in case it needs it' is not a BMP for turfgrasses grown on native Kentucky soils.

Professional turfgrass managers (such as sport turf managers, golf course superintendents, sod producers, or landscape managers) may choose to apply sole-P fertilizers. Sole-P fertilizers should be applied with caution because misapplications can lead to significant environmental risk. Benefits of sole-P fertilizers include lower cost than NPK fertilizers and the ability to apply P more precisely to smaller areas such as golf course putting greens.

Regardless of your level of expertise, P should be applied at a time when the turfgrass has the greatest opportunity to use it. For cool-season turfgrasses such as tall fescue and bentgrass, an efficient time to apply would be during late spring and again in the autumn months (Table 1). For warm-season turfgrasses such as bermudagrass or zoysiagrass, the suggested time to apply P is during summer months. Applying P to either cool or warm-season turfgrasses during winter months is not a BMP because both species are normally dormant and have little to no ability to absorb applied nutrients. Applying slow-release P during winter months has not been shown to be any more beneficial than waiting until spring or early summer when the turfgrass begins to grow out of dormancy.

Golf courses, sport turf, and sod production represent unique turfgrass systems. Turfgrass grown under these conditions may be subject to excessive stresses requiring the turf to constantly reestablish itself. Under these conditions, additional P may be warranted. Be mindful that applying P to turfgrass grown on soils with Mehlich III P concentrations ≥ 10 ppm does not normally result in appreciable increases in turfgrass growth and quality.

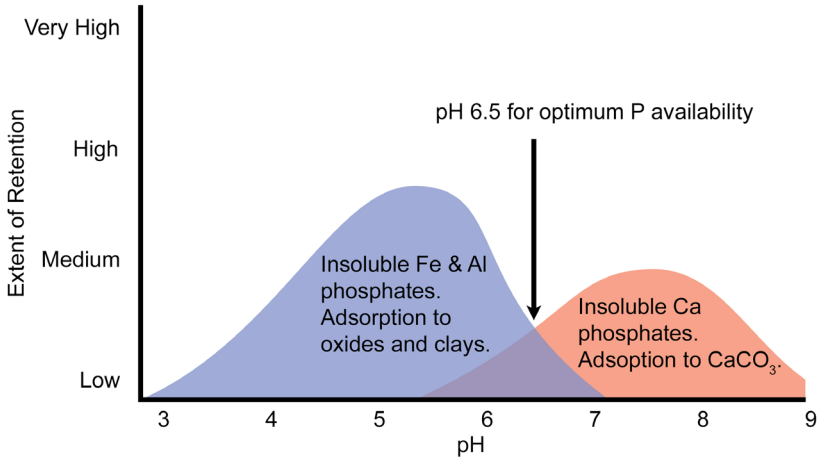

Figure 2. Soil pH influences P solubility. Adapted from Stevenson, Cycles of Soil, 1986

Table 1. Suggested timing and amounts of phosphorus to apply to turfgrasses grown in Kentucky when soil Mehlich III phosphorus levels are less than 10 ppm *and* turfgrass appears unacceptable

	May	June	July	August	September	October	November
	Pounds of P_2O_5/1,000 ft^2						
Cool-season grasses	0.25	-	-	-	0.25	0.25	0.25
Warm-season grasses	-	0.25	0.25	0.25	0.25	-	-

For home lawns, the total annual amount of P applied should not exceed 1 pound/1,000 ft^2 unless an additional soil test indicates Mehlich III P levels remain less than 10 ppm.
During turfgrass establishment, annual P amounts may exceed 1 pound/1,000 ft^2 if the initial soil test P level is less than 10 ppm Mehlich III P.

Phosphorus Sources

When naturally available soil P is too low to meet the turfgrass needs, P may be applied as one of numerous P fertilizers. Nearly all P sources used in turfgrass management originated from mined P, usually apatite (a form of calcium phosphate). Once applied, P sources will have vastly different reactions in the soil. In most soils, P is immobile and the solution concentration of P is highly dependent upon pH and P source, thus, an understanding of P source reactions is essential to maximize the efficient use of applied P.

Ordinary and Triple Superphosphate

Mined apatite is reacted with either sulfuric or phosphoric acid to form ordinary or triple superphosphate (OSP and TSP, respectively). OSP and TSP have a guaranteed analysis of 0-20-0 and 0-46-0, respectively. OSP and TSP are highly water soluble and considered neutral fertilizers because they have little influence on soil pH.

Monoammonium and Diammonium Phosphates

Both monoammonium (MAP) and diammonium phosphate (DAP) are manufactured by reacting ammonia with phosphoric acid. MAP and DAP have guaranteed analyses of 11-48-0 and 18-46-0, respectively. MAP is a good choice for high pH soils because the soil pH immediately adjacent to the fertilizer particle may be reduced to 3.5, which can result in more of the nitrogen (N) and P being available for plant uptake.

DAP is the most used fertilizer in the world and is a good choice for acidic soils because the application of DAP results in a pH of 8.5 immediately around the fertilizer granule. When DAP is applied to high pH calcareous soils, the P is immediately bound by calcium to form dicalcium phosphate and the N will volatilize because ammonium is highly soluble and easily converted to ammonia gas. Over time, the soil pH will return to the initial soil pH due to the acidity generated by the conversion of ammonium to nitrate (nitrification). However, in the time required to reduce the soil pH back to its initial level, much of the P will have been lost to precipitation and N will have been lost to volatilization. When soil pH exceeds 6.5, volatilization of N from DAP can exceed 30% of applied N and can be 5 times greater than that of MAP and 2 times greater than that of urea and ammonium sulfate. Thus, DAP should not be used on high pH, calcareous soils.

Liquid Phosphorus

Phosphorus may be applied as a liquid or as a foliar spray. Liquids are applied in water at 80 gallons per acre or greater, whereas foliar sprays are designed to remain on the leaf surface and are applied at lower rates near 40 gallons per acre. In either case, P in liquid form is usually as phosphoric acid. The ammoniated P sources previously mentioned may also be used as a liquid, but phosphoric acid is more common because it only contains P and it tends to be the least expensive liquid source. The P concentration of liquid P fertilizers vary greatly because the phosphoric acid must be diluted in water and may be blended with other components, such as N and K.

Organic Phosphorus

Most, if not all, natural organic fertilizers are manufactured from plant or animal wastes and contain a component of P. Typical P concentrations of organic fertilizers range between 1% and 7%. Organic P fertilizers contain both inorganic and organic P with the ratio of inorganic P:organic P varying widely depending upon the source. However, on average, P in organic fertilizers is roughly 50% organic and 50% inorganic. Thus, half of the total applied P would immediately contribute to soil solution P whereas, the remaining organic P would require mineralization to be converted to a plant-available form.

Natural organic fertilizers are often viewed more favorably than synthetic fertilizers due to a perceived reduction in environmental risk. However, natural organic fertilizers may increase environmental risk compared to synthetic fertilizers with respect to P. Caution should be taken when using natural organic fertilizers to minimize the risk of P leaching and/or runoff. When natural organic fertilizers are applied at rates sufficient to meet N needs, more P may be applied than the turfgrass can utilize leading to excess P lost to the environment. Thus, natural organic fertilizers should be applied as a supplemental N source or applied based upon the rate of P, without exceeding University of Kentucky P recommendations for turfgrass.

Summary

P is a plant essential element, and most Kentucky soils provide sufficient P to sustain acceptable turfgrass without additional P applications. In rare circumstances where P is required, an understanding of the plant and soil reactions with P will help you build a more efficient nutrient program. Be mindful that unless soil test P concentrations are less than 10 ppm Mehlich III P, the application of P to turfgrasses will increase costs and environmental risk and may provide little to no benefit to the turfgrass.

References

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