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How Phosphorus Addition and Removal Affecting Soil Test P Index

Hailin Zhang, Gordon Johnson and Bill Raun
Department of Plant and Soil Sciences

The nature of phosphorus in soils

Phosphorus (P) is an essential element for plant growth. It is taken up by plants from soils, utilized by animals that consume plants, and returned to soils as organic residues. Although the available forms of phosphorus for plant uptake are orthophosphate (HPO_4^{2-} and $H_2PO_4^-$), P exists in many different forms in soils. The formula P_2O_5 is normally used on fertilizer analysis reports and soil test recommendations, but this form does not exist in either fertilizers or soils.

There are three pools of P in soils: solution P, active P and fixed P. The solution pool is very small and only contains a fraction of a pound of P per acre. P in this pool, including orthophosphate and small amounts of organic P, is readily available to plant use. It is continuously replenished by the active P pool. The active P pool is the P in the solid form but it is relatively easily released to the soil solution. The fixed P pool contains inorganic phosphate compounds that are very insoluble and organic compounds that are resist to mineralization by microorganisms in the soil. Similar to the relationship between soluble and active P pools, some slow conversion between the fixed P pool and the active P pool does occur in soils.

The phosphate in fertilizer and animal manure is initially quite soluble in water and available for plant uptake, but various reactions take place and make the phosphate less soluble and less available when the fertilizer and manure P comes in contact with soil. Therefore, the amount of P applied to a field can not be completely recovered by a soil test.

What is the soil test P index?

In order to predict the soil's capability to supply P during a crop growing season, several soil test methods have been developed to simulate plant P uptake. Soil test P has been calibrated with crop yield response in different parts of the state to identify the degree of sufficiency and the amount of fertilizer P needed to correct any deficiency. The soil test P result is called soil test P index (STP). OSU Soil, Water and Forage Analytical Laboratory uses the Mehlich 3 extraction method to generate STP, which is the most commonly used method in the world. However, soil test labs in other states may utilize different method and get different results for the same soil sample. STP may include all the soluble P and most of the active P, but it is not the total P of the soil.

How do phosphorus addition and removal affect soil test P index?

Phosphate is nonvolatile and forms relatively immobile compounds in soils. Any removal of P from soils by harvesting or addition of P to soil in the form of fertilizer or organic materials will affect STP. A long term research experiment conducted at the OSU Agricultural Experiment Station at Lahoma documents the effect of soil-P depletion and enrichment from 27 years of annually applying 0 to 80 lb/acre fertilizer P for annual winter wheat production (Figure 1). The soil test P index is well correlated with net P input. About 14 lb P_2O_5/acre is required to raise or lower the STP by 1.0 unit for this silt loam soil. The amount of P_2O_5 needed to change STP may vary slightly with soil texture, pH and other soil properties. There may be differences between inorganic P fertilizer and organic P sources, such as, animal manure and biosolids. P from surface applied manure may raise STP faster than incorporated manure because manure is not mixed well with soils when it is not incorporated.

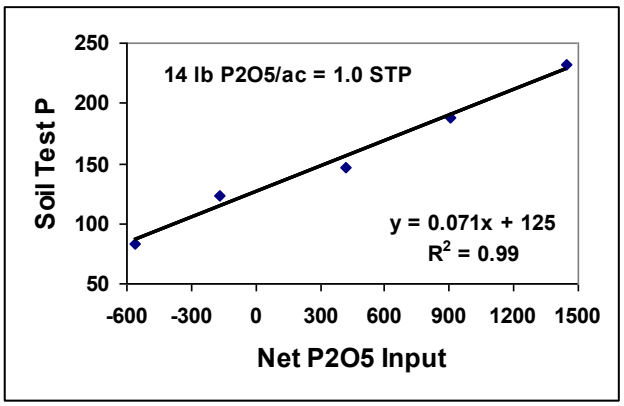

Figure 1. Changes in soil test P resulting from 27 years of fertilizer input and wheat grain removal in Lahoma, OK.

How long does it take to increase STP by 100 units with poultry litter application?

Poultry litter is normally land applied to pastures in eastern Oklahoma based on crop nitrogen requirements. The ratio of N to P required by plants is about 8 to 1, which is much higher than the ratio in poultry litter (about 1 to 1). Therefore, a buildup of P in soils will result if application rate is based on N needs. Producers and environmentalists are interested in knowing how fast soil P is built up at reasonable application rates. Assuming STP increases by 1 unit with 14 lb P_2O_5 addition, and 4 tons of bermudagrass per acre is harvested annually which removes about 32 lbs. of P_2O_5, it would take about 22 years to increase STP by 100 if only 2 ton litter per acre is applied annually. However, it only takes 4 years if litter rate is 8 tons/acre (Figure 2).

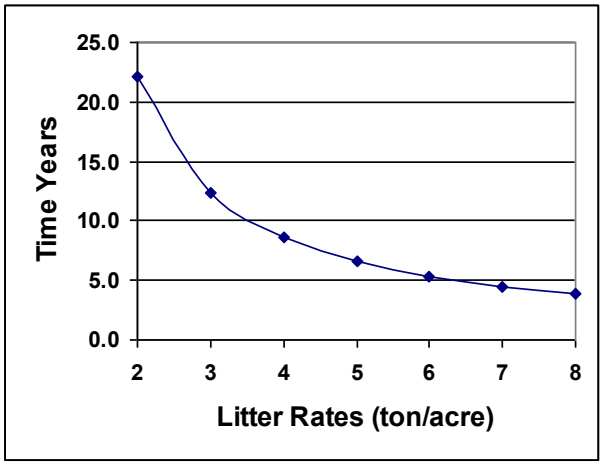

Figure 2. Time to increase STP by 100 units at different litter rates and 4 ton forage harvest.

How long does it take to decrease STP by 100 units using forage removal?

Some fields have already built up with high levels of P in the soil due to continuous poultry litter application. New regulations set a soil test P limit for additional litter application. For example, no animal manure can be land applied if soil test P is over 400 in Oklahoma. Therefore, some efforts have been made to reduce P in those fields with high yielding forage crops and/or legumes. However, it may take a long time to see a significant soil P reduction. Figure 3 illustrates the time needed to reduce STP by 100 at different forage yields. It takes about 30 years to reduce STP by 100 if 5 tons of forage is removed from the field every year.

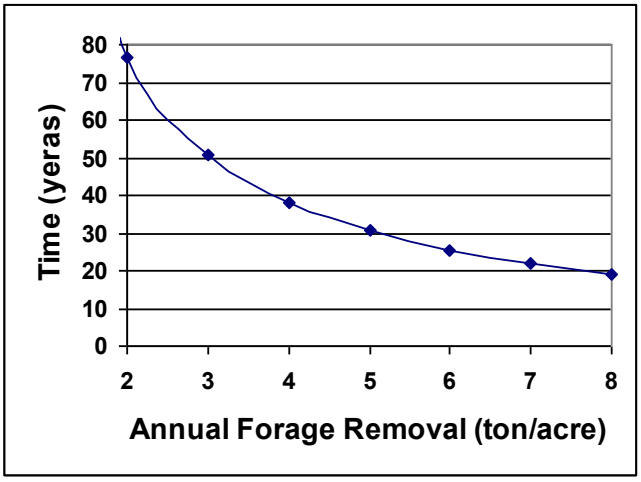

Figure 3. Number of years needed to decrease STP by 100 units with different amounts of forage harvested.

Summary

Phosphorus exists in different forms in soils. Soil test P is an estimation of plant availability of soil P during the growing season. The index of STP is affected by P addition to and removal from the field. P can buildup fast with high rates of manure application, but it may take a long time to mine it down to normal levels with crop removal. The best management practice for P is to apply it based on crop needs and prevent it from buildup.