Soil resources of phosphorus

This article continues a series that provides producers with information to aid in phosphorus (P) management and in understanding environmental issues related to P management. This article focuses on the presence and behavior of P in the soil.

The nature, amount, distribution, and chemical composition of P compounds in soil are closely related to the classic factors of soil formation--climate, organisms, parent material, topography, and time. Because we have tilled, fertilized, drained, and allowed soils to erode, the form and amount of P in the surface horizon has changed.

P in the soil profile

Iowa soil profiles typically contain thousands of pounds of P per acre, but only a small fraction of this P is available to growing plants. The reaction of P fertilizers and P crop availability depends on application methods and soil conditions, including soil minerals, soil acidity, moisture, and temperature.

Soil test values for crop production are obtained from the surface horizon because that is generally the most active area of P uptake by plants. However, many plants extend root systems 5 to 6 feet or deeper in the soil profile (including corn and soybean). Therefore, it is not only available P in the surface horizon but throughout the soil profile that contributes to plant uptake. Differences in available P in subsoils among soil series can result in different interpretations of soil tests and P fertilizer recommendations--even when soil test P levels of surface horizons are similar.

Forms of P in the soil, P reserves, and the P cycle

As weathering of minerals occurs, soluble P is released. Soluble P may percolate through the soil, be used by plants or microorganisms, enter the reactive pool, be transformed into secondary minerals, or be lost in runoff.

- Total P is all the P that exists in soils. Different forms and "pools" of P can be grouped on the basis of chemical nature and solubility in the soil system.
- Solution P is a very small amount, can be drawn out with water or a dilute salt, and is mostly the plant available orthophosphate form.
- Reactive P is a solid phase that can be easily released to the soil solution as plants use P. The ability of the reactive P to replenish the soil solution or soluble P gives the soil P fertility for crops. Reactive P is the fraction most soil tests extract.
- Occluded and P in primary minerals is relatively insoluble and resistant to weathering. It

is found in primary soil minerals, in secondary minerals (that result from weathering of primary minerals), or physically encapsulated by secondary minerals.
- Organic P is found in organic matter.

Plants primarily take up orthophosphate P. Organic P returned to the soil in plant residue and manure is not available to growing plants until the organic material is decomposed and released as inorganic orthophosphate P. This process is called mineralization and is most rapid in warm, moist, and well-drained soils. The equilibrium of P in soils is strongly influenced by soil pH. When other factors are constant, maximum availability of P for plant growth occurs under slightly acid to neutral conditions (pH range 6.5-7.0).

Soil erosion and total P

The total P concentration of the "plow layer" (upper 6 or 7 inches) for many Iowa soils is quite high, on average perhaps 0.05% but with an upper range of over 0.1%. If we assume a plow layer weight of 2,000,000 pounds per acre and 0.05% total P, the total P content is 1,000 pounds. This means that each inch of the plow layer in an acre contains over 140 pounds of P. Only a small fraction of this total P is available to growing plants, however.

The average soil loss due to water erosion for cropland in Iowa is about 5 tons per acre. On average 5 tons of sediment would contain about 5 pounds of P. If soil loss is 15 tons per acre, then P loss would be 15 pounds per acre. Reducing P loss by controlling erosion is an important part of P management.

Summary

Proper management practices (such as soil testing and erosion control) increase efficiency of P use by crops, increase crop productivity, improve environmental quality, and increase profits.

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