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## Phosphorus Basics

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# Phosphorus Basics

## **Abstract**

This article is a continuation of a series of articles aimed at aiding in the development of a phosphorus (P) management strategy for Iowa producers. In this article, we discuss

1. P as a plant-essential nutrient,
2. role of P in human and animal nutrition,
3. P uptake by plants, and
4. removal, monitoring, and application of P.

## **Keywords**

Agronomy

## **Disciplines**

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# INTEGRATED CROP MANAGEMENT

## Phosphorus Basics

This article is a continuation of a series of articles aimed at aiding in the development of a phosphorus (P) management strategy for Iowa producers. In this article, we discuss

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### Phosphorus as a plant-essential nutrient

There are 17 nutrients essential for plant growth and crop production, and a deficiency of any can have an adverse effect on plant growth, maturity, and yield. The major nutrients or macronutrients include nitrogen, P, and potassium; secondary nutrients include calcium, magnesium, and sulfur; and the micronutrients include boron, chloride, copper, iron, manganese, molybdenum, zinc, and nickel. Carbon, hydrogen, and oxygen are obtained from air and water. Phosphorus is present in plant and animal cells and is vital to all plants for harvesting the sun's energy and converting it into growth and reproduction. In plants, P is an essential part of sugar phosphates; is involved in respiration and energy transfer via adenosine triphosphate (ATP); and is a part of ribonucleic acid (RNA), deoxyribonucleic acid (DNA), and membrane phospholipids. Without an adequate supply of P, plant growth is diminished, maturity delayed, and yield reduced.

When plants die, P is returned to the soil, where it can be used by soil microorganisms and other plants. The P cycle repeats until P is lost at the bottom of the seas and becomes fixed in sedimentary rock, to be released if the rock surfaces and is weathered.

### Role of P in human and animal nutrition

Humans and other animals obtain P from eating plants, and use it to make bones, teeth, and shells. It is also an important constituent of cell membranes, DNA, RNA, and ATP. Phosphorus is excreted as phosphate and organic-P compounds. Soil microbes recycle P for plant uptake, thereby making it available to all animals. On average, the human body contains 1 3/4 lb of P, with the overwhelming amount found in bones. The remainder is used for other body processes including the metabolism of red blood cells and ATP production. ATP is an energy-rich compound that fuels activity in the body's cells. Muscle movements are fueled by the energy liberated during the removal of phosphate from ATP. Because ATP in muscle cells is used rapidly during contraction, ATP has to be continually resynthesized to supply energy to the cells.

Phosphorus is important in the diets of livestock as well. Phosphorus and other nutrients are required for bone strength and the production of muscle. Low-P diets are associated with a reduction in average daily gains because feed intake declines. For example, common livestock feedstuffs (such as corn and soy meal) in a swine diet do not offer high percentages of available P. Only 14 percent of P in corn and 31 percent of soybean meal P can be digested by swine. Because a large percentage of P is unavailable, much of it is excreted.

Some strategies to reduce P in manure from livestock feeding operations are the use of phytate and low-phytate corn. Adding a phytate enzyme to animal feed helps in digestion of the organic-P compound, making more P available to the animal. Low-phytate corn has shown positive results in the areas of bone strength, average daily gain, and feed efficiency. If producers use low-phytate corn in swine rations, the P lost through excretion and wasted feed can be greatly reduced.

## Phosphorus uptake by plants

Nutrient uptake by crops depends on nutrient supply in the soil, root surface area, and root activity. Roots are able to absorb only the nutrients that come into contact with living and active cells, so P uptake is dependent on the condition of a plant's root system. Nutrients contact the root surface by three mechanisms: diffusion, mass/bulk flow, and root interception.

**Diffusion** is the movement of molecules through the soil. The size of soil particles and moisture level determine how long it takes nutrients to reach the roots. Higher water content and smaller soil particle sizes provide a more direct path to the root surface. The distance P travels by diffusion in soils is extremely small. Therefore, an active and large root system is important. Phosphorus is supplied to roots primarily by diffusion and root interception.

**Mass flow/bulk flow** is the movement of nutrients to root surfaces through soil water movement. Mass flow to roots is driven by plant transpiration, however, mass flow is not a major pathway of P movement to plants.

**Root interception** is the growth of root structures into new soil that contacts plant-available P. Root growth is important because it provides additional root surface area for P uptake.

## Phosphorus removal, monitoring, and application

Phosphorus exists in large quantities in most Iowa soils; however, much of the P is present in mineral and organic forms that are not immediately plant available. Phosphorus becomes plant available as minerals weather or by microbial degradation. Over the years, P fertilizer and manure have been used to augment the amount of plant-available P in soils and, subsequently, improve crop yields.

When reasonable P soil test levels have been achieved, producers have some flexibility in their management of P inputs. A buildup of plant-available P has been accomplished on many soils through continued use of fertilizers and manure. But management systems that do not add supplemental P will eventually experience a decline in plant-available P, and, as a result, reduced crop yields.

Phosphorus uptake (total amount in plant material) and crop removal (removed in harvested crop) are large for agronomic crops. The portion not taken off the field in harvested grain or

forage is returned in crop residues and available for future crops. Examples of P removal in harvest crops include the following: corn, 38 lb P<sub>2</sub>O<sub>5</sub> for each 100 bu of grain harvested; corn silage, 35 lb P<sub>2</sub>O<sub>5</sub> per 10 tons chopped; soybean, 40 lb P<sub>2</sub>O<sub>5</sub> for each 50 bu of grain harvested; and alfalfa, 63 lb P<sub>2</sub>O<sub>5</sub> for each 5 ton of forage harvested. Continual cropping with no replacement of this P results in reduction of plant-available P in soils.

Phosphorus is chemically reactive with the soil. However, compared with the nitrogen cycle, the P cycle is less complex and P less easily lost from soils. Phosphorus is strongly adsorbed by soil particles and readily retained in soil. Due to this retention, high applications of P, in excess of P removal in harvested crops, push soil test levels and available P above agronomic need. Soil testing is the research-based method for monitoring crop-available P levels in soil and the need for P fertilization.

## Summary

Although much is known about P and its interaction with soils, there is still much to be learned about the relationships among soil management, P management, and P movement to surface water systems. As water quality criteria for P are refined, specific field, soil, and P management requirements need to be clearly defined for producers to maintain optimum P and production levels in their fields.

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