

# NEWS & VIEWS

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Dr. A.E. (Al) Ludwick,  
Western Director  
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## Phosphorus Mobility in Perspective

**PHOSPHORUS (P)** is an immobile nutrient. So when a P fertilizer material is applied to the soil it remains in place. This is generally true, but as with most generalizations there is more to the story and certainly exceptions to the generalization. The following discussion is intended to put *P mobility in perspective*.

### Fertilizer Phosphorus

The chemical form of P in fertilizer materials is phosphate ( $\text{H}_2\text{PO}_4^-$ ,  $\text{HPO}_4^{2-}$  or  $\text{PO}_4^{3-}$ ). Regardless of what fertilizer we add to soil, whether it is a dry product such as concentrated superphosphate (0-46-0), diammonium phosphate (18-46-0), monoammonium phosphate (11-52-0), or a solution product such as ammonium polyphosphate (10-34-0), for all practical purposes the fate of soil P is ultimately the same.

### Phosphorus in the Soil

When applied to the soil, the phosphate in each of the above products precipitates. Precipitation occurs rapidly and, therefore, phosphate tends to move very little...usually just a fraction of an inch in any single season. Precipitation occurs in both acid and alkaline soils. As shown in **Figure 1**, phosphate is precipitated in acid soils by iron (Fe) and aluminum (Al). Aluminum is most active precipitating phosphate at a pH of 5.0 to 5.5. Iron is especially active below pH 4.0 where phosphate is strongly fixed. Calcium (Ca) is primarily responsible for phosphate precipitation in alkaline soils, our dominant situation in the west, where the activity peaks around pH 8.0. Of the three processes...precipitation by Fe, Al or Ca...P is

relatively more available to crops when it is precipitated by Ca. Therefore, loss of phosphate (fixation) through precipitation is actually of less concern in alkaline than in acid soils.

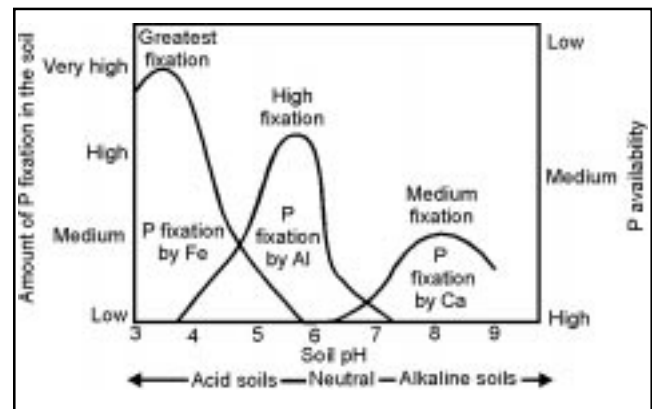


Figure 1. Phosphorus availability as affected by soil pH.

The fact that phosphate rapidly precipitates in soil is not necessarily a negative characteristic. As a result of precipitation, phosphate does not leach...at least very little and only over a long period of time. So it is not a potential hazard to contaminate groundwater supplies. Much has been written about the hazards of nitrate ( $\text{NO}_3^-$ ) and how to minimize its potential hazard. It is of concern because  $\text{NO}_3^-$  remains highly soluble in the soil and moves with the water. Environmental issues with phosphate generally relate to erosion of topsoil that carries phosphate on soil particles into surface streams and lakes. Stopping erosion is the best way to minimize movement of phosphate off agricultural lands.



Agronomic market development information provided by:  
**Dr. A.E. (Al) Ludwick, Western Director,**  
Potash & Phosphate Institute (PPI)  
P.O. Box 970, Bodega Bay, CA 94923-0970  
Phone: (707) 875-2163  
E-mail: [aludwick@ppi-far.com](mailto:aludwick@ppi-far.com)



## Managing Phosphorus Fertilizer

Another positive aspect of phosphate staying where it is placed is there is no guesswork as to where it might have migrated to several weeks or months after application. Growers can place the phosphate exactly where it is most available for the crop, and it will stay close to that spot. This simplifies management.

It is generally best to incorporate P into the soil in the zone of maximum root activity. This is not always possible or convenient for some crops, especially perennials... forage and hay crops, tree fruits and nuts, vines, etc. Topdressing is an option for those crops that have a lot of feeder roots close to the soil surface, such as forage and hay crops. As long as there is sufficient moisture near the soil surface, the roots can extract sufficient P to meet crop needs. Experience over many years has shown us that topdressing can be very effective in these situations. However, if the surface few inches of soil dries out for several weeks at a time then P may be what is commonly referred to as *positionally unavailable*. In other words, the P is in the soil, but in a position...in the dry surface layer...where the crop roots cannot obtain it.

Phosphorus will migrate downward in the soil profile over an extended period of time. In one study in Washington, topdressing 80 lb/A of  $P_2O_5$  annually to a fine sandy loam resulted in measurable downward movement to about 2 feet after 17 years.

Maximum movement of P can be obtained by placing it at a single point (concentrating it in the soil) and irrigating. This is easily accomplished in drip irrigation systems via fertigation or simply by placing the phosphate in a basin immediately below the drip point. Downward movement is sufficient to move significant P into the root zone of the crop, but shallow enough that loss due to excessive leaching is not a problem. This is illustrated in **Table 1** where P has migrated approximately one foot deep in a clay loam soil during one cropping season. Note that movement is greatest with the higher rate of application.

**Table 1. Distribution of drip-applied orthophosphoric acid to Panoche clay loam directly under the emitter.**

Soil depth, inches	$P_2O_5$ , 13 lb/A	$P_2O_5$ , 80 lb/A
	Increase in bicarbonate-soluble P, lb/A	
0-2	18	613
2-4	4	452
4-8	0	49
8-10	0	38
10-12	0	9

Horizontal P movement was somewhat less than vertical movement. Rauschkolb, University of California

Too often we generalize and simply state that P is an immobile nutrient. Under some conditions it pretty much is, staying within just a fraction of an inch of where it is placed. But given time and appropriate management, it can be moved into the soil profile...into the effective root zone. ■

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**Potash & Phosphate Institute (PPI)**  
655 Engineering Drive, Suite 110  
Norcross, GA 30092-2837

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