Photo by Brian Lindley.

Managing Phosphorus in No-Till

by Ray Ward

SCIENCE

Raymond C. Ward is a soil scientist & founder of Ward Laboratories at Kearney, NE.

Phosphorus is a highly important plant nutrient that is in short supply in many soils in the Great Plains as well as around the world. After carbon and nitrogen, phosphorus is often the next most limiting element for crop growth.

The prairie soils were high in organic matter (OM) when they were broken for crop production. The organic matter contained a large amount of nitrogen (N) and other plant nutrients. A large portion of the soil phosphorus (P) was held in the organic matter. As this organic matter was depleted by cultivation and erosion, and mined by crop removal, P deficiency became an increasing problem. P fertilization practices were implemented to help supply the needs of the crops. As we move to no-till, the rate of P fertilization might need to increase to meet the demands of more intensive crop rotations and rebuilding OM. However, some mechanisms in no-till improve P availability, so it isn't quite that simple.

Mycorrhizal fungi increase under no-till, and can assist some crop species in taking up P from soil.

Research has gradually revealed viable methods to evaluate the P status of soils and to effectively apply P. This article will explore how P reacts in soils and how P fertilization might differ in no-till practices.

Phosphorus Behavior in Soils

Plant roots take up phosphorus in two forms. The monophosphate ion, H_2PO_4, is the predominant phosphate type in soil solution when the soil pH is below 7 (acid). When pH is above 7 (alkaline), the predominant form is the diphosphate ion, HPO_4. Both forms are also called orthophosphates ('ortho' refers to the 4 oxygen atoms). These P-containing ions are attracted to calcium (Ca) ions in alkaline soils, and to iron (Fe), manganese (Mn), and aluminum (Al) in acid soils. The attraction causes the phosphate ions to attach to those other ions, forming more complex molecules that drop out of solution and cannot be taken up by the plant. Abundance of these phosphate-reacting ions (Ca, Fe, Mn, Al) varies

Photo by Doug Palen.

Harvest of grain removes large quantities of P from the field, which must eventually be replaced.

primarily with soil pH (see diagram on page 240); concentrations of these ions will dictate P availability to plants.

Availability of soil phosphorus is directly related to the solubility (ability to dissolve into soil water) characteristic of the various types of P-containing molecules. As plants remove phosphate ions from the soil water, this creates 'room' in the soil water for more orthophosphate molecules to dissolve from the soil particles. How rapidly the P in soil water is replenished depends on the solubility of the P-containing molecules on the soil particles.

In alkaline soils, the solubility of phosphorus is affected by the amount of calcium present. Calcium is the predominant element present in alkaline soils, and reacts with the HPO_4 ion to form dicalcium phosphate. Dical phosphate in alkaline pH has low solubility, but it is still soluble enough to supply P to the crop. As the crop takes up the HPO_4 from the soil solution, more HPO_4 dissolves from dical phosphate. Soil P tests will effectively measure the availability of P in alkaline soils.

In acid soils, the compound formed is *mono*cal phosphate, which is readily soluble. However, acid soil conditions result in iron, aluminum, and manganese becoming soluble especially at stronger acid levels (lower pH). When iron and aluminum become soluble they combine with the phosphate ion, with the resulting molecule dropping out of solution and remaining relatively insoluble; this begins to occur when soil pH is less than 5.5

To read the rest of this article, click here to purchase a PDF file of this article.