CERTIFIED CROP ADVISER

Soil Phosphorus Stratification

by Dr. Tom Bruulsema *CCA-ON*

Today's conservation tillage systems do a lot less mixing. When soils were moldboard plowed, the top six to ten inches of soil were inverted, aggressively blending in concentrated layers, bands or pockets of nutrients. In a regularly plowed field, a sample taken to two inches depth gave more or less the same result as one taken to the full depth of plowing.

With the advent of conservation tillage and no-till systems, however, that changed. Applied nutrients are no longer mixed as thoroughly into the soil. Crop residues stay on the soil surface, and release their nutrients there. For a nutrient like phosphorus (P) that moves slowly through soil, this means that the top two inches of soil now holds more available P than the layers below. In recent studies of farm fields across Ohio and in the western Lake Erie watershed—conducted by Heidelberg University, USDA-ARS and Ohio State University—soil test P in the top two inches is now on average 43 to 48 percent higher than in the top eight inches, and in some farm fields it is as much as three times as high.

Why might stratification matter? Two possible reasons: for the crop and for the environment.

For the crop, concentrating the nutrients might mean lower availability, particularly if the top layer dries out and the roots can't be active there. However, that's rarely been found to be an issue for no-till production. It's quite possible that the thicker crop residue layer improves water retention enough to allow roots to be more active near the surface. But deeper placement can encourage deeper roots.

For the environment, however, when water leaves the field by surface runoff, its concentration of dissolved P is influenced by the availability of P in the soil to which it is exposed. The same is true for water that reaches the tile drains by preferential flow through macropores (cracks in clay soils, or earthworm channels) or surface inlets. Most crop fields discharge water, either directly off the soil surface, or through tile drains. Ultimately this water ends up in ponds, reservoirs and lakes. Many of these receiving waters are sensitive to increases in P concentrations and loadings, and algal blooms may result.

So how does stratification affect P loss? For any given soil, the concentration of P in the runoff water increases with soil test P in the soil to which it is exposed. The amount of increase in loss per unit increase in soil test, however, varies considerably from soil to soil. A review of 17 runoff studies, published in 2005, found that the increase in concentration of dissolved P in runoff for each part per million increase in either the Bray P1 or Mehlich-3 P soil test ranged from 0.4 to 13 parts per billion (ppb). The most typical value, however, was around 2 ppb. It may not seem like a large increase in P loss, however, because dissolved P in drainage water from soils testing in the agronomic optimum range is often already close to a level that can support an algal bloom, small increases can matter. The effect is chronic, not acute. The increase in dissolved P in the water leaving the field is not drastic. But the effect continues with every rainfall event. So for water quality, soil test stratification matters, and managing it is a key part of "right place" in 4R Nutrient Stewardship.

What can be done?

1. If you currently broadcast P fertilizer or manure in no-till or conservation tillage fields, consider ways to inject or apply in subsurface bands instead.
2. Sample fields to two depths separately, 0-2" and to your typical sampling depth. Consider analyzing the shallow sample for an environmental test like P sorption, or water extractable P.
3. If the degree of stratification is substantial, and the soil test P level in the shallow sample markedly exceeds the optimum range, consider a tillage operation to mix all or part of the topsoil. Such a tillage operation should be done at a time of year when potential erosion or runoff events are least likely (often, late summer or early fall). Protect against soil erosion by leaving adequate crop residue cover, or plant cover crops.

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Dr. Tom Bruulsema is a Certified Crop Adviser employed by the International Plant Nutrition Institute as their Northeast Director located in Guelph. Contact Tom at (519) 835-2498 or tom.bruulsema@ipni.net

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