farmdoc DAILY

Department of Agricultural and Consumer Economics, University of Illinois Urbana-Champaign

Nutrient Movement off Frozen and Snow-Covered Soil

Emerson Nafziger

Department of Crop Sciences
University of Illinois

December 23, 2019

***farmdoc daily* (9): 238**

Recommended citation format: Nafziger, E. "Nutrient Movement off Frozen and Snow-Covered Soil." *farmdoc daily* (9): 238, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, December 23, 2019.

Permalink: https://farmdocdaily.illinois.edu/2019/12/nutrient-movement-off-frozen-and-snow-covered-soil.html

Snow has now fallen throughout much of Illinois, and temperatures have dropped going into the last weeks in 2019. With the recent Illinois Nutrient Loss Reduction Strategy biennial report highlighting P and N levels in Illinois waterways, this is a good time to review the application of nutrients on frozen and/or snow-covered soils.

Last spring, after a short and often-muddy fall fertilizer season, a considerable amount of fertilizer—mostly P in the form of DAP or MAP and K as KCl—was applied during the first week of March when the soil surface was frozen. Between March 3 and March 8, 2019, minimum air temperature averaged less than 15 degrees F, and maximum temperature averaged less than 30 degrees over most of Illinois. This was one of the few times last winter when soils were frozen and there was little or no snow; and many took the opportunity to apply P and K.

Unfortunately, an inch or more of rain fell over most of Illinois south of I-80 followed fertilizer applications on frozen soils in early March 2019. Most of this rain fell during the day on March 9, and as evidenced by the rapid rise in streams and rivers, a great deal of this rainfall ran off the (then-frozen) soil surface.

As part of the ongoing water monitoring that IFCA conducts within their Keep it 4R Crop Program, several samples of water moving out of fields after this rainfall event were collected. In fields where P and K had not been applied recently, average levels of chloride, nitrate-N, ammonium-N, and phosphate-P were 2.3, 0.7, 0.1, and 0.3 ppm, respectively. We expect to see such low values, since these nutrients don't tend to remain on or near the soil surface during the winter.

Samples from fields where P (MAP) and K were applied on frozen soils in early March had an average of 39.0 ppm chloride, 1.2 ppm nitrate-N, 8.3 ppm ammonium-N, and 19.1 ppm phosphate-P. These fertilizers don't contain nitrate, so the low nitrate-N number was expected. Both MAP and KCl are highly soluble in water, though, and the elevated chloride (K wasn't measured), ammonium, and phosphate levels are a clear indication that the rain dissolved fertilizer nutrients and moved them off the field. Samples from a few other fields showed increased sulfate levels, probably coming from ammonium sulfate spread before it rained.

When there is an event like this, higher concentrations come off initially, and concentration declines with time. So we can't know how much really came off these fields. But as a conservative estimate (because samples were taken some hours after the rainfall began), let's imagine that the samples had average concentrations, and that an inch of water per acre moved off these fields. An acre-inch of water weighs about 226,600 lb, so if an inch runs off with 19.1 ppm of phosphate-P, about 4.3 pounds of P, or 9.9 lb of P_2O_5, moved off each acre. KCl is about 47.6% chloride, so 39 ppm chloride would convert to movement of about 9.7 lb K or 11.7 lb K_2O per acre.

Another reason for concern about loss of P from events like this is that dissolved P at 20 ppm is 400 times the level (0.05 ppm) in surface waters that many consider to be the point where water starts to become impaired—where P supports the growth of undesirable algae. The major loss from an event like this economic—some of the fertilizer paid for is simply gone from the field. Even more nutrients have likely moved off higher elevations to lower elevations, producing a new "variable-rate" application—but one whose pattern is not likely to line up with existing soil nutrient levels.

Even though events like this are relatively rare, movement of nutrients off fields in this case was both predictable (the rain was forecast) and preventable. It's understandable that retailers want to apply nutrients when the (frozen) soil will support application, and many producers are in favor of doing this before it gets muddy again. As it turned out, there were not many days in the spring of 2019 when soil conditions were dry enough to allow for surface application of P and K. There are, however, few fields in Illinois with P and K levels low enough to have decreased yields had fertilizer application had been delayed to after planting, or even to the fall, after harvest. Delaying application to the fall would mean adjusting the rate to account for removal by another crop, but would have meant little or none of the loss and redistribution that can result from application to frozen soils.

What about soils that are snow-covered but may not be frozen? Soluble nutrients like MAP/DAP and potash can melt their way down to the soil surface and possibly into the soil, but a "slow melt" with little movement of water off the field is an ideal that we seldom see. With nutrients dissolved in the snow, any water moving off the field as snowmelt will carry a lot of nutrients with it. Deeper snow helps wide (floater) tires stay out of the mud, but it also makes it more likely that rain will fall before the snow finishes melting, and when that happens, a lot of water can leave the field, carrying nutrients with it.

Posted to the UI Bulletin on December 16, 2019: http://bulletin.ipm.illinois.edu/?p=4931