Stewardship SPECIFICS

No. 17

Soil Nitrate and Leaching

Nitrate (NO_3^-) is a common anion salt in soil. It is an important nutrient source for plants, but too much nitrate in drinking water or surface water can be undesirable.

Sources of Nitrate

Soil organic matter is the major reservoir of nitrogen (N) in most agricultural conditions. For example, a soil with 2% organic matter would contain over 1,500 lb N/A (1,680 kg N/ha) in the surface 6 in. (15 cm). Soil microbes will convert a relatively small portion of this organic N to nitrate each year through the processes of mineralization and nitrification.

Nitrate is also found in geologic forms in unique conditions. For example, natural deposits of nitrate are found in the extremely arid desert of Chile. In some environments, a significant amount of nitrate is found in rocks and minerals.

Bacteria associated with legume crops can convert N gas in the atmosphere into compounds for plant growth. When these and other crop residues decompose, nitrate is eventually released into the soil. Animal manures and composts also add N to soil, some of which converts to nitrate. Homes that use a septic tank to treat waste will release nitrate-enriched effluent into the soil.

Commercial fertilizers are a major input of nitrate in agricultural soils. Fertilizers commonly contain N in the form of urea, ammonium, or nitrate. However, all of these forms will ultimately be converted to nitrate by soil bacteria. There is no difference between nitrate from fertilizer and nitrate produced by microbes.

Nitrate Leaching Process

Water moving through soil carries many soluble ions with it in the process of leaching. Leaching is a natural phenomenon that occurs whenever rainfall or irrigation exceeds the water-holding capacity of soil. Since nitrate is soluble in water and mobile in the soil, it readily moves with any water passing beyond the rootzone. Given sufficient time and water, nitrate may eventually reach groundwater.

Leaching regularly occurs when rainfall exceeds the ability of the soil to hold water. In irrigated agriculture, farmers occasionally add surplus water in excess of crop requirements to flush salts below the root zone. Salts can accumulate without this periodic flushing of the soil. However, intentional leaching should only occur when nitrate concentrations are low and generally avoided during the growing season.

An effective way to minimize nitrate leaching is match fertilizer additions to the rate of plant nutrient uptake. For example, young seedlings use very little nitrate, but when plants are rapidly developing, they may take up over 20 lb NO_3^-/A each day (5 lb N/A or 5.5 kg/ha). By the end of the season little residual nitrate should remain in the soil.

Multiple applications of small amounts of fertilizer may help minimize nitrate-leaching loss compared with a single large dose. In some circumstances, a slow-release fertilizer may be appropriate for maintaining low soil nitrate concentrations.

Planting a cover crop can be a good strategy for recovering nitrate that remains in the soil following harvest of the preceding crop. Converting nitrate into plant tissue changes the N into stable organic compounds that are not subject to leaching.

Soil testing can be a useful tool for determining the amount of nitrate present. This quantity of nitrate can be deducted from the N fertilizer requirement. Additionally, nitrate present in irrigation water can partially replace N fertilizer.

In all cases, matching the amount of nitrate in the root zone with the plant nutrient requirement will help minimize leaching. Careful water management is also required to avoid moving nitrate deep into the soil.

http://commons.wikimedia.org/

http://www.ag.ndsu.edu

Fertilizer, crops and crop residue, and manures all provide important contributions to the soil nitrate-N pool.

FOR FURTHER READING:

Meisinger, J.J., and J.A. Delgado. 2002. J. Soil Water Conserv. 57: 485-498.

Wortmann, et al. 2013. Report 189. University of Nebraska–Lincoln, Iowa State University, Kansas State University, University of Missouri-Columbia, USDA-ARS. (Accessed on-line 12 Aug., 2013). 32 p.

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This *Stewardship Specifics* is one of a series of condensed summaries of issues impacted by nutrient stewardship written by scientific staff of the International Plant Nutrition Institute (IPNI). This series is available as PDF files at www.ipni.net/publications.

Ref #13071