Nitrogen as a Plant Nutrient

by Ray Ward

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SCIENCE

The author's prequel on soil organic matter was in the March '03 Leading Edge.

Nitrogen atoms are integral parts of plant proteins, chlorophyll, DNA, enzymes, and many other compounds important for plant growth. Plant roots take up nitrogen in the nitrate (NO_3^-) and ammonium (NH_4^+) ionic forms. The predominant molecule taken up is nitrate. Ammonium is 'preferred' by plants during very early growth, but as growth advances and demand increases, plants take up most of their nitrogen in the nitrate form.

The amount of nitrogen fertilizer to apply depends on the nitrogen-supplying capability of the soil. The "pool" of available nitrogen sources includes: 1) organic[1] N sources such as animal manure, sewage sludge, and compost, as well as soil organic matter (OM), 2) nitrogen-fixing bacteria (e.g., *Rhizobia*) associated with legume plants, 3) free-living nitrogen-fixing microbes, 4) nitrogen fertilizer, and 5) fixed soil ammonium. All of these sources of nitrogen are converted to nitrate in time.

Photo by Doug [illegible]

The author describes water percolation from his 'deep-six' location in a soils pit during the '03 Whirlwind Expos.

Since nitrate is the predominant form of N used by plants, measuring the residual nitrate in the root zone before planting the intended non-legume crop is an important step in estimating N fertilizer needed. The residual soil nitrate test is a good measure of available nitrate in most Great Plains soils where nitrate leaching is minimal, the exceptions being certain soils prone to leaching and denitrification. Nitrate is soluble; therefore, it is mobile in soil water. Where rainfall is great enough to move water deeper than the root zone prior to or during the growing season, the residual soil nitrate test may be a poor estimate of available nitrogen. In poorly drained soils that remain wet for a period of time, nitrate can be lost to the atmosphere during a process called denitrification. (These mechanisms will be described in more detail later in the article.)

Determining an appropriate amount of nitrogen fertilizer to apply depends on many factors. First, you need to know the characteristics of the intended crop: what is the N requirement of the crop per yield unit, and what is the yield potential? Mineralization[2] of soil organic N is an important factor: a high mineralization rate will reduce the need for N fertilizer. Mineralization of soil organic N is governed by weather (moisture, temperature) as well as the quantity and characteristics of soil organic matter. Legume crops in rotation will increase the rate of mineralization temporarily. Adequate N nutrition of previous non-legume crops will narrow the C:N ratio and accelerate mineralization of those residues (see the March '03 *Leading Edge* article for further discussion of residue decomposition and mineralization). Once the crop requirement is determined and mineralization estimated, the measured soil nitrate can be subtracted to arrive at the amount of fertilizer N to apply.

Fertilizer N Sources

In the selection of an N fertilizer source, crop producers have concerns involving volatilization, immobilization, and availability of N fertilizer. In most studies, when care is taken to avoid potential loss of N, all sources of N fertilizer applied at the same rate per acre had an equal

[1] 'Organic' in this article is in the sense used by chemists to denote molecules containing carbon.

[2] Mineralization is the breakdown of organic molecules to inorganic, or mineral, by loss of carbon.