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Using the Pre-sidedress Soil Nitrate Test to Improve Nitrogen Management in Vegetable Cropping Systems

Nitrogen (N) is essential to nearly every aspect of plant growth, but it is one of the most difficult nutrients to manage. When plant available N exceeds crop demand, nitrate accumulates in soil increasing the risk of ground water contamination. High levels of available N can produce succulent plants that are more susceptible to environmental stress and pest pressure. When plant-available N is too low, crop health and productivity suffer. The key to successfully managing N is to determine the relatively narrow range between too much and too little – this is not an easy task. Having an understanding of the forms of N in the soil and the factors that influence its behavior will help improve management of this dynamic nutrient.

The N Cycle

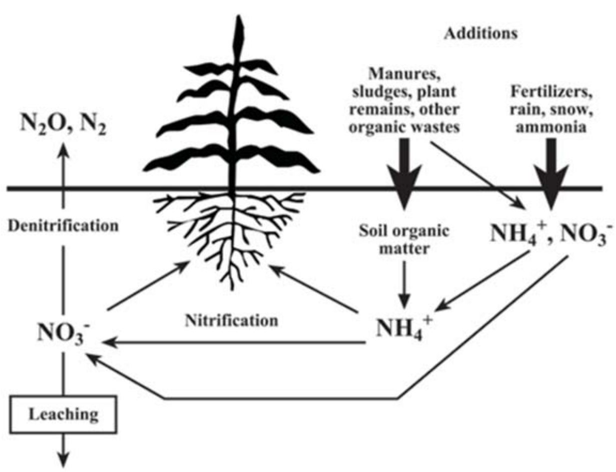

Figure 1. Generalized illustration of the nitrogen cycle.

Efficient and effective N management requires a practical knowledge of the nitrogen cycle. The N cycle is extremely dynamic and, as illustrated in Figure 1, its behavior in soil is complex. Regardless of the form of N added to, or originally in the soil, it undergoes many transformations, which determine its fate. Ultimately, there are two forms of plant available N: ammonium (NH_4) and nitrate (NO_3). Unfortunately, these two forms are also easily lost from soils. Of the two, NO_3 leaching accounts for the vast majority of N losses from agricultural soils, a significant environmental concern.

Ammonium (NH_4) and Nitrate (NO_3)

NH_4 is lost from the soil surface through volatilization. Volatilization losses are greatest where animal manure or fertilizers containing NH_4 are surface applied without incorporation. Once NH_4 is incorporated into the soil, volatilization losses are small. Also, NH_4 is not very mobile in soil so leaching losses are minimal. However, in warm moist soils NH_4 is rapidly converted to NO_3 (by the microbial process, nitrification), which is extremely mobile and reactive. Under water-logged soil conditions, soil microorganisms convert NO_3 to molecular nitrogen (N_2) and nitrous oxide (N_2O), which leave the soil as gases (denitrification). Even in well-drained soils, NO_3 is easily leached below the root zone contributing to ground and surface water contamination.

Soil Organic Matter

Soil organic matter contains the largest pool of soil N, which can comprise more than 90 percent of total N in soil. The total amount of organic matter N in the plow layer of agricultural soils is impressively large. As a rule of thumb, you can assume that for each 1% of organic matter in the surface 6" or 7" of soil, there are 1000 lbs of N per acre. Thus, a soil with 3% organic matter contains about 3000 lbs of N per acre. However, only a small portion of the N contained in organic matter is made plant available each growing season through the process of mineralization (the microbial conversion of organic N to inorganic plant available N). It is generally assumed that 2 to 4% of organic N will be mineralized each growing season. This is roughly equivalent to 20 to 40 lbs of available N per acre for each 1% of organic matter in the surface 6" or 7" of soil. Keep in mind, there are a number of factors that can influence mineralization so this is a very rough estimate.

Because mineralization is carried out by soil microorganisms, it is extremely sensitive to soil moisture and temperature; therefore, weather and irrigation have a dramatic influence on the rate of mineralization. The nature, or quality, of the soil organic matter also influences mineralization rate. Where soil organic matter content (and quality) has been increased by repeated applications of animal manure, compost, or other organic residuals, the portion of mineralizable organic N is typically higher than in soils with no organic amendment history. Similar changes in mineralization rate often occur where green manures or sod-crops are grown in rotation.

Meeting Crop N Demand

The aim of managing N is to ensure an adequate supply of available nitrogen that is well synchronized with crop demand. In most agricultural soils, N from mineralization of organic matter can satisfy a significant portion of crop N needs, but the balance may need to be met using fertilizer additions. Because N mineralization varies among fields, and is significantly influenced by weather, one challenge is to accurately predict *how much* fertilizer is necessary, and the other is to know *when* to apply (see fig. 2 in the box below). Using the Pre-sidedress Soil Nitrate Test (PSNT) is a well-researched tool that can help farmers know if and how much N fertilizer to apply.

Nitrogen Uptake by Annual Crops

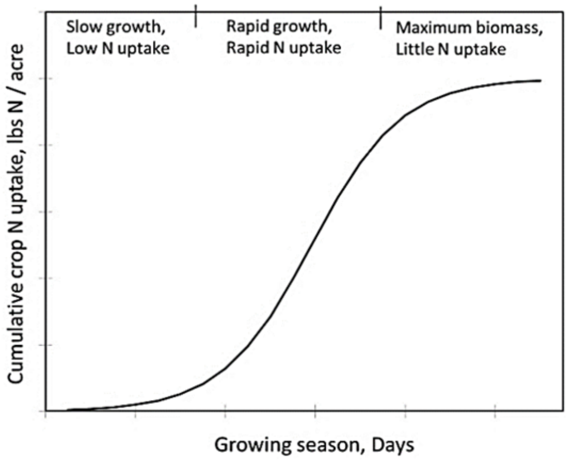

Figure 2. Generalized nitrogen accumulation curve for annual crops.

The N accumulation pattern for annual crops is very similar to biomass accumulation. Early in the season, when crop growth is slow, crop N needs are very small. A starter fertilizer is generally sufficient to satisfy those needs. Any soil NO_3 in excess of crop N needs during this period is prone to leaching and/or denitrification losses. The next phase of crop development is characterized by rapid vegetative growth. The N demand during this phase is the highest of the growing season. As much as 85% of the total N uptake occurs during this period. Efficient uptake of fertilizer N can be achieved by sidedressing fertilizer N just prior to this phase.

Soil Testing to Predict N Needs

The dynamic nature of the N cycle and its sensitivity to weather limits the value of routine, pre-season soil testing for predicting N availability during the season in our humid environment. However, under certain circumstances, in-season soil testing has proven useful. The PSNT, developed by Dr. Fred Magdoff at the University of Vermont in the early 1980's, was originally intended to help estimate the amount of available N for field corn in fields where manure had been applied and/or forage legumes were grown in rotation. Over the last thirty years research conducted in the Northeast has shown the PSNT useful for improving N management of several other crops including sweet corn, peppers, pumpkin, winter squash, cabbage, and lettuce. The PSNT is most suitable for use with annual crops, which accumulate N rapidly within a single growing season.
The PSNT is especially useful where large amounts of N from mineralization are expected, and the test works best when pre-plant and starter fertilizer N rates are less than about 50 lbs N per acre. PSNT samples are collected about a week prior to the rapid growth phase of development (see figure 2), and provides an indication of how much N has been made available from mineralization. During wet springs with heavy leaching rains, the PSNT will also provide some indication of how much N remains in the root zone.

As with all soil testing, information from a PSNT should be used along with the grower's experience and knowledge of the field. Interpretation of the PSNT is also crop specific. Research in the Northeast has shown that when the soil NO_3-N level is above 20 to 25 ppm there is rarely an economic response to the application of fertilizer N for sweet corn. Research with pumpkin, winter squash, cabbage, and peppers indicates that when the soil NO_3-N level is 25 to 30 ppm, the application of sidedress fertilizer N is not required. When PSNT values are below those threshold levels, the appropriate rate of sidedress N should be determined based on the level of NO_3-N reported, previous N application, realistic yield expectation, the field's management history, and growing season conditions.

Sampling Instructions

The most critical step in soil testing is collecting the sample. It is important that you take the necessary steps to obtain a representative sample; a poor sample could result in erroneous results and recommendations.

- Step 1: Determine the area to be represented. Areas with different yield potential due to past management or differences in soil type should be sampled separately.
- Step 2: Collect sample about one week prior to the appropriate time for sidedressing. Using a clean bucket and sampling tube, collect at least 15 to 20 soil cores to a depth of 12- inches. Avoid starter bands and atypical areas of the field.
- Step 3: Break up soil cores, remove stones and plant debris, and thoroughly mix the sample in the bucket.
- Step 4: Scoop out and spread about one cup of soil into a thin layer on a sheet of non-absorbent paper. Microbial activity can rapidly change the concentration of nitrate in warm, moist soils, so it is important to rapidly dry samples; a fan set on low will help speed the drying process.
- Step 5: Place dry samples in UMass Soil Testing Laboratory cartons (obtained from the lab) or a plastic zip-lock bag. Label each sample with your sample ID (e.g., field name), and deliver (in person or by mail) along with a completed submission form and payment, to the address listed on the front. Submission forms may be found at soiltest.umass.edu

Results are generally available within 24 to 48 hrs. Be sure to provide your preferred method of receiving results and appropriate contact information.

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