Adapt-N: Incorporating weather, soils and management information to provide more precise in-season N recommendations for corn.

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Corn production systems as a whole generally have low fertilizer N uptake and recovery efficiencies (RE). Through on-farm experiments in six North-Central US states, average RE was determined to be 37% with a standard deviation of 30% (Cassman et al., 2002). This suggests both low nutrient use efficiency and high potential N losses to the environment. It also indicates that there is considerable opportunity to develop tools for more precise estimation of corn N requirements. Development of such tools is particularly important given high N fertilizer prices and the environmental consequences of large N losses from agriculture.

Corn response to applied N is often highly variable, and economically optimal N rates (EONR) may range from zero to 225 lbs N ac^{-1}. Early season weather, particularly precipitation, has been highly correlated with EONR and nitrate-N export via subsurface drainage from crop fields. Data from a number of studies suggest that early season weather impacts the amount of crop available soil N that accumulates due to soil organic matter mineralization. It is this variation in soil N levels in the early season that contributes to variability in EONR since the sum of fertilizer N and crop available soil N from SOM mineralization make up the pool of crop available N. Therefore, if the size of this pool can be estimated, EONR can be adjusted through in-season N applications that are based on the estimated soil N pool. This should improve the precision of corn N management. (A second important determinant of EONR is the occurrence of post-sidedress drought. This limits corn yield potential and N uptake. At this time, weather forecasts are not accurate enough to make adjustments in EONR.)

Why is the amount of soil N sensitive to early season weather? In normal years, accumulation of mineral N in the root zone from soil organic matter (SOM) mineralization may contribute about half of the required crop N. Uptake of N by the corn crop lags behind SOM mineralization so that, during the late spring, high quantities of soil mineral N (SMN) reside in the soil profile, mostly in the nitrate form and are subject to losses. This is a critical period for N losses and seasonal N availability. If excessive rainfall occurs during this time, significant N losses may occur from leaching or denitrification (with warm soil). In cool springs, N mineralization is slow, and the accumulation and subsequent loss of SMN is smaller when excessive wetness occurs.

Optimum N fertilizer rates for corn, therefore, vary greatly and primarily depend on (i) the amount of readily mineralizable nitrogen in the soil at the beginning of the growing season, (ii) early growing season N losses related to the occurrence and timing of excess wetness and high soil temperatures during those times of saturation (affecting denitrification rates), and (iii) the occurrence of drought during the mid and late season, resulting in unattained yield potential. Static methods for determining fertilizer rates are limited because they neglect the temporal dynamics in soil N. Application of static recommendations generally results in excessive fertilization in years with dry springs, and inadequate fertilization in years with high early season N losses. In many cases, especially when fertilizer to crop price ratios are low, farmers opt to use higher rates (insurance fertilizer) for the uncommon case where they experience a wet early season. In the majority of years this results in excessive fertilizer application, unnecessary expense, and increased losses that potentially impact the environment.

Approaches for N management in corn production systems.

There are several different approaches to N management for corn production, including mass-balance and the maximum return to N (MRTN), soil-based tests such as pre-plant nitrate test (PPNT), the Illinois Soil Nitrogen Test (ISNT) and the pre-sidedress nitrate test (PSNT), remote and proximal crop sensing to detect incipient N stress, and post facto tests such as end-of-season lower stalk nitrate. Each of these approaches provide useful information for determining fertilizer N requirements but have had limited success as tools for estimating year-to-year variability in EONR. Our approach has been to use high resolution climate data and crop/soil simulation modeling combined into an easy-to-use web-based tool (*Adapt-N*) to provide in-season N recommendations in both field corn (grain and silage) and sweet corn production systems. This is an adaptive method that takes advantage of increasingly sophisticated environmental databases (e.g., radar-based precipitation estimates) that can be accessed in real-time. These data are used as input information for dynamic soil and plant models to estimate crop growth and soil N dynamics, and provide more precise estimates of seasonal crop N needs. The basis of the *Adapt-N* tool is the Precision Nitrogen Management or PNM model that tracks soil and crop N flows in corn production systems in the Northeast U.S. The PNM model has two components: a soil processes model (LEACHN) (Hutson, 2003; Hutson and Wagenet, 1992) and a corn N uptake, growth and yield model (Sinclair and Muchow, 1995). The PNM model has been calibrated for the range of corn N management practices typically found in the Northeast U.S.

Adapt-N: An adaptive N management tool for corn production systems.

Adapt-N (http://adapt-n.eas.cornell.edu/) was developed to provide improved in-season N recommendations based on simulation of soil N dynamics and corn N uptake for conditions in the Northeast U.S. The *Adapt-N* tool provides a simple interface where the user provides information about a field, that the model uses to obtain an N recommendation for that field. This information includes field location (latitude and longitude), soil textural class (fine, medium, coarse), slope, tillage practices, organic matter content, and timing and amounts of previous N inputs (fertilizer, manure, and sod). Crop information includes crop maturity class, expected harvest population, planting date, and expected yield. For sweet corn, expected yield menus are provided for both processing varieties (tons/acre, unhusked ears) and fresh market varieties (ears/acre). *Adapt-N* can also be used for site-specific management by performing simulations for areas with different soil organic matter contents and textural classes in a field.

In the *Adapt-N* tool, the PNM model accesses the most up-to-date high-resolution climate data as input information based on user input of latitude and longitude for a given field. The availability of such high-resolution data is necessary for the successful adoption of adaptive N management strategies because spatial patterns of temperature and particularly precipitation during Northeast U.S. growing seasons are highly variable over short distances. This variation cannot be adequately described at the current density of weather stations in the Northeast U.S. (20 to 40 miles apart), limiting the use of weather station data for farm-level simulation of N processes. The Northeast Regional Climate Center and the Cornell Center for Advanced Computing have developed methods to produce and distribute high resolution temperature data (3 x 3 mile gridded) and precipitation data (2.5 x 2.5 mile gridded) for the Northeast U.S. These data are updated daily on advanced database servers and are automatically accessed by the *Adapt-N* tool. Simulating early-season soil N levels with high-resolution climate data facilitates more precise estimates of in-season N needs at the farm level and can improve N use efficiency in corn production.

Background information on the tool, including the calculation of the N recommendation is available via links to factsheets on the front page of *Adapt-N*. An additional dimension of the use of high-resolution climate data for adaptive N management is the ability to incorporate climate change into N management. Future climates are generally predicted to involve more extreme events and periods of excessive wetness and prolonged drought. The *Adapt-N* approach allows for accounting of such extremes and incorporation into N management.

References

Cassman, K.G., Dobermann, A., Walters, D.T. (2002) Agroecosystems, nitrogen-use efficiency, and nitrogen management. Ambio 31:132-140.

Hutson, J.L. & Wagenet, R.J. (1992) LEACHM: Leaching Estimation And Chemistry Model: A process-based model of water and solute movement, transformations, plant uptake, and chemical reactions in the unsaturated zone. Continuum Vol. 2, Version 3. Water Resources Institute, Cornell University, Ithaca, NY, U.S.A.

Hutson, J.L. (2003) Leaching Estimation And Chemistry Model: A process-based model of water and solute movement, transformations, plant uptake, and chemical reactions in the unsaturated zone. Version 4. Dept. of Crop and Soil Sciences, Research series No. R03-1. Cornell University, Ithaca, NY, U.S.A.

Sinclair, T.R. & Muchow, R.C. (1995) Effect of nitrogen supply on maize yield: I. Modeling physiological responses. Agronomy Journal. 87:632-641.