The long view of nitrogen recommendations from Nebraska Extension

Charles Shapiro, Soil Scientist – Crop Nutrition
Charles Wortmann, Soil and Nutrient Management Specialist
Richard Ferguson, Soil Specialist
Tim Shaver, Nutrient Management Specialist
Brian Krienke, Extension Educator
Bijesh Maharjan, Soil and Nutrient Management Specialist
Gary Hergert, Emeritus Soil Nutrient Management Specialist

Introduction:

Nitrogen use for corn production is under continuous scrutiny. The farmer seeks to optimize its use for profit and efficiency. Many of our Natural Resource Districts have had Nitrogen Management Plans for 25 or more years requiring periodic certification and reporting of soil N, fertilizer N application, irrigation water N content, N application, and yield. Concern about surface water is highlighted by the recent lawsuit over nitrate-N in the Des Moines IA water supply. Several ag corporations have launched on-line tools to manage N throughout the season such as Climate Corp and Pioneer. Some consultants advise on N management using Adapt-N or similar tool. Not all these private tools are completely documented, meaning that they do not publish the underlying models used to make estimates of N use or loss.

The NRCS uses UNL recommendations as published in our NebGuides and Extension Circulars, as well as our experience and research data base to inform their recommendation and procedures. These publications are revised at least every five years with reinterpretation of past and new information although the history and rationale for changes are not documented in the Extension resources. This paper is an attempt to fill in some of the gaps about how and why UNL recommendations have changed over the years.

This paper is authored by current UNL nutrient management Extension faculty but this is an ever changing group. In 2015 Dr. Gary Hergert retired, at least two others intend to retire before mid-2018, and Dr. Ferguson will assume the role of Interim Department Head for the Department of Agronomy and Horticulture. Dr.'s Shaver, Maharjan and Krienke are relatively recent to our group and plan to continue as UNL specialists on N and nutrient management. Contributions of Agricultural Research Service and other UNL scientists have been and continue to be a valuable part of information supply for developing and refining recommendations.

The objective of this paper and the talk that will accompany it is a look back at how we have arrived at our present nitrogen recommendation procedures and also a glimpse forward to where we think it might go. In addition, we have compiled a bibliography of N related publications from UNL soils faculty. At the time of this writing we do not have a link, but it will be highlighted at http://cropwatch.unl.edu/soils for a while after these clinics.

History:

The longest serving soil fertility specialist of the above authors is Dr. Shapiro (1984), followed closely by Dr. Ferguson. Dr. Wortmann is a native Nebraskan and did graduate study in Nebraska, left for positions in Africa, and returned to Nebraska in 2001. When Drs. Shapiro and Ferguson started, the corn fertilizer N algorithm or formula considered yield goal and residual soil nitrate-N based on available research at the time to achieve profitable yield. Residual soil nitrate-N was inputted as pounds of N with an adjustment for sampling depth to estimate a credit for crop available N from the residual nitrate-N in the top 6 ft of soil. In addition to yield goal and residual soil nitrate-N, the formula accounted for the effects of previous crop, applied manure, and nitrate-N in irrigation water.

Recommended N in lbs/ac: [(0.9 x YG)/(1-0.0008*YG)] + 50 - SoilN-lbs

with YG = Yield Goal and SoilN-lbs = soil nitrate in lbs N/6 ft depth

Before Dr. Shapiro came on board, the soil fertility position at the Northeast Station, as the Haskell Ag Lab was called back then was filled by Dr. George Rehm. Other soil fertility faculty at that time were Drs. Anderson (Scottsbluff), Gary Hergert (North Platte), Ken Frank (Clay Center), and Ed Penas (Southeast) , Richard Wiese and Don Sander (Lincoln). This group generated a large dataset from 81 site years of N rate trials over several years which was analyzed by Gary Hergert who then proposed revisions of the corn N algorithm. These included:

1. The use of the weighted average for residual soil nitrate-N concentration for a soil sample depth of at least two feet;

2. Consideration of soil organic matter level with a formula for estimating the release of N from soil organic matter;

3. Revision of the soybean N credit.

The new formula, which is what we are currently using is the following:

N rate (lb N/acre) = [35 + (1.2 x EY) - (0.14 x EY x OM) - 8 x SoilN-ppm - Other credits] x f_A x f_R

EY = expected yield (yield goal, bu/acre)
OM = organic matter (%)
SoilN-ppm = weighted average soil nitrate test (min 2-ft) ideally before planting in spring
Other credits: legumes, manure, irrigation

Added after NSFP Project, see below points
f_A = application timing adjustment factor
f_R = price ratio adjustment factor

These changes were accepted and the new formula was published in our corn NebGuide in the early 1990s. The credits for irrigation water N, manure N, and other previous crops remained with some revision over time. Default values for when measured values are not available are used for residual soil nitrate-N and for the amount of irrigation water applied when records of past years are inadequate.

Between 2002-2004, 34 site-years of research were conducted across Nebraska to evaluate high yield corn responses to N, P, K, and S through the project called the Nebraska Soil Fertility Project (NSFP). Drs. Doberman, Blumenthal, and Tarkalson also participated in NSFP. Results of NSFP were used to validate or update our recommendations for irrigated high yield situations. The earlier 81 site-years included both irrigated and rainfed sites, but NSFP sites were all irrigated. Three published papers report NSFP results while results were also used in other papers. These papers detail the experimental procedures and report the major findings. These findings included:

1. The corn N formula estimated fertilizer N need very well on average but the results found much year-to-year variation in the economically optimal N rate (EONR). The NSFP results did not indicate an opportunity to improve the predictive power of the corn N formula to better account these variations in EONR.

2. The corn N response curve differed for continuous corn compared with corn following soybean and the response to fertilizer N was less variable for corn following soybean (Figure 1). We have discussed using two procedures, one for corn on corn and one for corn on soybean ground, but this has not been developed.

3. Dr. Doberman revised our corn nitrogen recommendations to account for the price of nitrogen and value of corn, so that our initial recommendation can be adjusted based on the corn price: nitrogen price ratio. Therefore the recommended corn N rates are higher with low N cost relative to corn price, but lower when nitrogen is relatively more expensive. Factor Fr above.

4. The corn N formula was revised to consider whether the time of N application adjusting fall, spring/preplant, or predominantly in-season with respective N rate adjustments of 105, 100, and 95% of the predicted N. Factor Fa above.

The corn N calculator is an Excel spreadsheet tool that allows the user to enter data to calculate an N rate with and without the economic analysis http://cropwatch.unl.edu/soils/software (download the Excel Spreadsheet 'Corn Nitrogen Recommendations Calculator' link found on that page). In the spreadsheet the details of the calculations are listed and the assumptions used.

5. The corn N calculator considers more information and does more detailed calculations compared with the published corn N formula in Extension Circulars EC117 and EC155. The main difference is it assumes different bulk density values for sandy and fine textured soil when converting soil nitrate from a concentration to weight. The corn N calculator differentiates the soybean N credit for soybeans based on soil texture.

6. The corn N calculator does not calculate environmental implications.

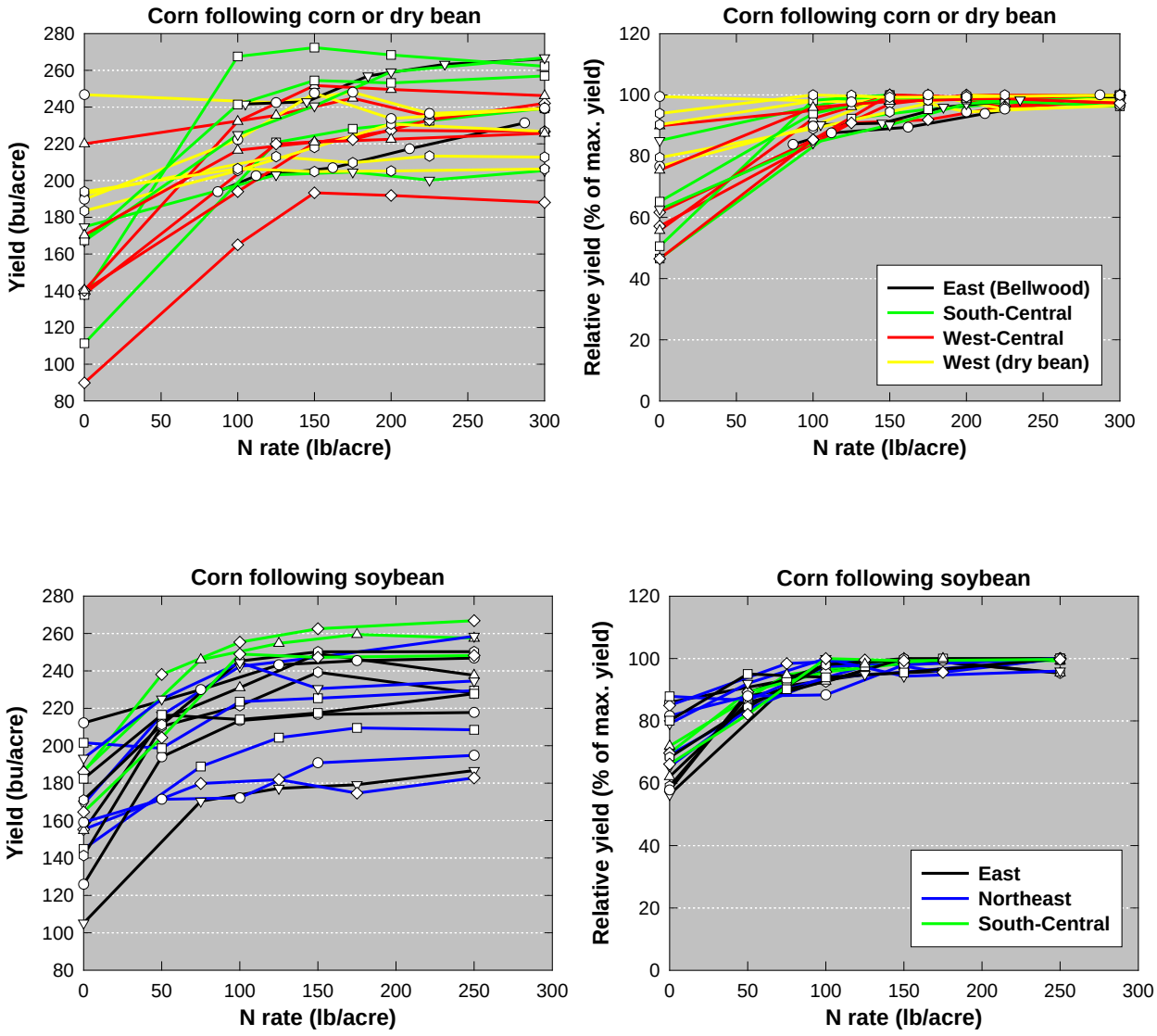

Figure 1. Corn yields response to N in absolute yield and relative yield for continuous corn and corn following soybeans. From the NSFP project 2002-2004.

The above discussion is focused on the N rate determination and a bit on the timing. However, critical to the N rate determination is having a soil nitrate assessment of the field that is representative of the area of the field that is to be fertilized. In the mid to late 1980s research was conducted to assess deep nitrate variability.

More recent corn N research has addressed improvement of N use efficiency such as by determining effects of: use of fertilizer N use efficiency products such as inhibitors and controlled release products; in-season N application guided by leaf canopy color; N recovery from applied manure and other organic products; and crop residue harvest.

The first NebGuide addressing use of crop canopy color to guide in-season N application addressed the use of a chlorophyll meter (Minolta SPAD 502), the precursor to the crop sensors that are more popular today. This work was conducted by the Agricultural Research Service division located at the University of Nebraska and was led by Dr. Schepers with help from Dr. Varvel and Dennis Francis. Another proceedings article could be written on the development of sensor technology and development of its use in corn nitrogen decisions.

This article was intended to just focus on the work related to N rate development, and we recognize it is related to other aspects of N management. The bibliography cited in beginning will be more comprehensive than just the N reate decision.

Selected publications of interest:

Dobermann, A., C.S. Wortmann, R.B. Ferguson, G.W. Hergert, C.A. Shapiro, D.D. Tarkalson, D. Walters. 2011. Nitrogen Response and Economics for Irrigated Corn in Nebraska. Agron. J. 103:67-75.

Ferguson, R.B., C.A. Shapiro, G.W. Hergert, W.L. Kranz, N.L. Klocke, and D.H. Krull. 1991. Nitrogen and irrigation management practices to minimize nitrate leaching from irrigated corn. J. Prod. Agric. 4:186-192.

Hergert, G.W., R.B. Ferguson, C.A. Shapiro, E.J. Penas, F.B. Anderson. 1995. Classical statistical and geostatistical analysis of soil nitrate-N spatial variability. Chapter 13. P. 175-186. *In* P.C. Robert, R.H. Rust, and W.E. Larson, (eds.). Site-specific management for agricultural systems. ASA. Madison WI.

Kranz, W.L., C. Burr, B.S. Farmaha, P. Grassini, G.W. Hergert, S. Irmak, D. Martin, A. Nygren, C.A. Shapiro, T. Shaver, and G. Zoubek. 2015. Irrigation and Nitrogen Management: User Education/Certification Program. EC2008. University of Nebraska–Lincoln Extension Division. http://extensionpublications.unl.edu/assets/pdf/ec2008.pdf (http://water.unl.edu/waternmgt)

Olson, R.A., F. N. Anderson, K. D. Frank, P. H. Grabouski, G. W. Rehm and C. A. Shapiro. 1987. Soil Testing Interpretations: Sufficiency vs. Build-up and Maintenance. In SSSA Spec. Pub 21. Soil Testing: Sampling, Correlation, Calibration, and Interpretation. p.41-52.

Wortmann, C., C. Shapiro, A. Dobermann, R. Ferguson, G. Hergert, D. Walters, and D. Tarkalson. 2012. High yield corn production can result in high nitrogen use efficiency. Better Crops 4:14-15.

Shapiro, Charles A., Richard B. Ferguson, Gary W. Hergert, Charles Wortmann, and Daniel T. Walters. 2009. Fertilizer Suggestions for Corn. EC117. University of Nebraska Extension Division. http://extensionpublications.unl.edu/assets/pdf/ec117.pdf

Shapiro, C.A., J.S. Schepers, D.D. Francis, and J. F. Shanahan. 2006. Using a chlorophyll meter to improve N management. NebGuide G1632 (Revised, October 2006).

Shaver, T., Brand, J. I., Hergert, G. W., Krienke, B., Shapiro, C., Wortmann, C. Nutrient Management for Agronomic Crops in NE (EC155). Tim Shaver (Ed.), Lincoln, NE: EC155. UNL Extension. http://extensionpublications.unl.edu/assets/pdf/ec155.pdf

Wortmann, C., Jansen, J., Van Liew, M., Ferguson, R., Hergert, G. W., Shaver, T., Shapiro, C. Nitrogen Loss Assessment Tool (N-LAT) for Nebraska: Background and Users Guide. http://extensionpubs.unl.edu/publication/9000016369584/nitrogen-loss-assessment-tool-n-lat-for-nebraska/