NITROGEN RECALIBRATION FOR WHEAT IN NORTH DAKOTA

D.W. Franzen, G. Endres, J. Lukach, R. Ashley, and K. McKay
North Dakota State University, Fargo, North Dakota

Abstract

The general formula for determining N fertilizer rate in North Dakota for about thirty-five years has been *N-rate = (2.5 X Yield Potential (or Yield Goal) less credits from previous crops and soil test nitrate-N from a 2-foot soil core composite.* Historically high fertilizer N costs and the ability to fertilize within fields rather than whole field N management has resulted in a reexamination of N calibration data, and an effort to expand the modern N calibration database with new field experiments. Although a work- in-progress, the study has suggested that the old formula does not predict optimum N rates, and that consideration of agriclimatology zones and indexes of N mineralization potential may need to be factored into future formulas for better addressing current production and economic conditions.

Introduction

Although North Dakota is a top-5 state in the production of a number of commodity crops, including dry edible beans, sunflower, flax, sugarbeet, potatoes, barley, canola, and now has significant acreage of corn and soybean, the number one crop in the state is spring wheat in terms of acreage. North Dakota is the nations' leader in spring wheat and durum wheat production. The N-rate formula (Figure 1) used for the past thirty-five years has been *N-rate = (2.5 X Yield Potential (or Yield Goal) less credits from previous crops and soil test nitrate-N from a 2-foot soil core composite)* (Franzen, 2007).

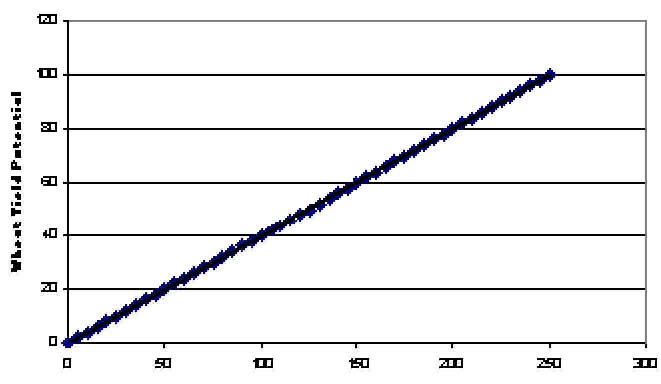

Figure 1. Present N-rate formula that calculates recommended N-rate from yield potential, previous crop credits and soil test nitrate-N taken to 2-ft in depth.

The current formula suggests that the calculation is predictive; that N-rate may drive yield. Although under N-deficiency conditions this may be accurate, when environment limits yield, N-rate can do little to overcome the restrictions of drought, heat and disease. Experiences with variable-rate fertilizer applications in over thirty whole-field site-years of experiments in North Dakota have shown that N-rate may over-recommended in more productive areas of fields, and under-estimated in less productive areas of fields. It may take more N/bu in less productive areas of fields due to less mineralization potential and less water availability to move N to roots than in productive areas of the field (Franzen and Long, 2006).

The formula also predicts a linear response to fertilizer, which is unusual compared with many datasets that suggest a curvilinear response. In a curvilinear response, as fertilizer rate increases, the return in yield from each increment of fertilizer applied becomes less. This response curve would have serious implications on economic rate of N from 1970 compared to today because of the differences in N costs in reaching a rate in which the cost of N applied equaled the return to N applied from yield and quality of spring wheat/durum. Nitrogen fertilizer costs in 1970 were about $0.10/lb N. The cost of N today has ranged from $0.30/lb N to $0.55/lb N from 2005 to the present. One might expect that if the N response curve from empirical data was indeed a curve, there would be an N rate at a given price of grain and protein where additional N would not provide a positive economic return.

The objective of this on-going study is to retrieve and analyze archived data from 1970 to the present, and to generate modern data to determine a more practical N-rate formula for current production and economic conditions.

Methods and Materials

A search of old files and published works, peer-reviewed and otherwise, was conducted. A total of about 80 site-years of N calibration data were collected. Most of the data was associated with a geographical location, usually a nearby town. Some of the data was associated with an organic matter analysis. All of the data was associated with a soil test nitrate-N analysis. Some of the data was associated with previous crop, although before 1990 it was unusual for wheat to be grown following a legume in most of the state.

Beginning in 2005, new N calibration studies were initiated by some of the researchers at the Research and Extension Centers at Carrington, Minot and Langdon. In 2006, some limited funding was gathered from Georgia-Pacific Company to test their slow-release N products against present commercial sources, and N calibration work was made possible out of several more locations. Through 2007, a total of about twenty modern N calibration site-years have been collected. In all, with archived data and modern data, a total of about 400 data-points comparing yield/protein and N-rate/credits has been accumulated. Soil from plot-work conducted in 2006-2007 was analyzed for organic matter content, and also was sent away to the University of Illinois ISNT (Illinois Soil Nitrogen Test) laboratory for analysis.

Results

Using archived data and modern data from 2005-2006 (Figure 2), the response of yield to available-N is linear. However, the zero-N rate does not product zero-yield. A zero-N rate produces about 22 bu/a. The rate of N determined to produce additional yield is about 7 lb N/a, not 2.5 lb N/a as our present formula is written.

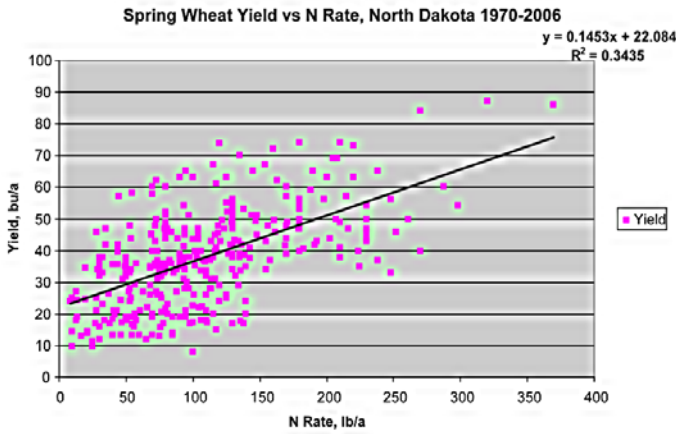

Figure 2. Spring wheat yield compared with N rate, 1970-2006.

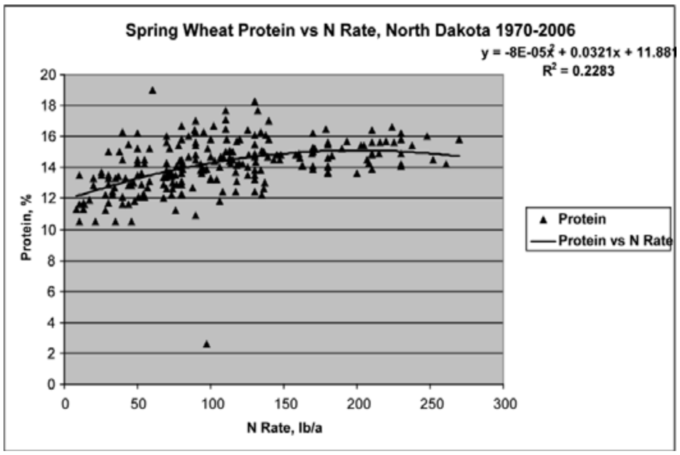

Figure 3. Spring wheat protein response with N-rate (total known available-N).

Unlike the yield response, the protein response is curvilinear (Figure 3). Maximum protein is achieved statewide in the archives with about 175 lb N/acre. Protein is an important component of economic analysis of spring wheat. When protein is less than 14%, there is a substantial dock. When protein is greater than 14%, up to a level of 15%, there is often, but not always a protein premium paid to growers. Beyond 15%, there are no additional incentives for protein. In some years, this premium is very large, but in most years it is about 1/3 the amount deducted as dockage for low protein.

Using the technique introduced by Nafziger and Sawyer (2005), the return to N using the state-wide archive was developed. Figure 4 shows the return to N using a $3/bu elevator price for spring wheat, with protein above or below 14% considered. For this and other return-to-N calculations, the protein predictive model from the protein response curve was incorporated into the spreadsheet for N rate and yield, and the economic result of the protein predicted from N rate was added or subtracted from the return in yield X wheat price. This was done for N costs of $0.20, $0.30, $0.40 and $0.50/lb N.

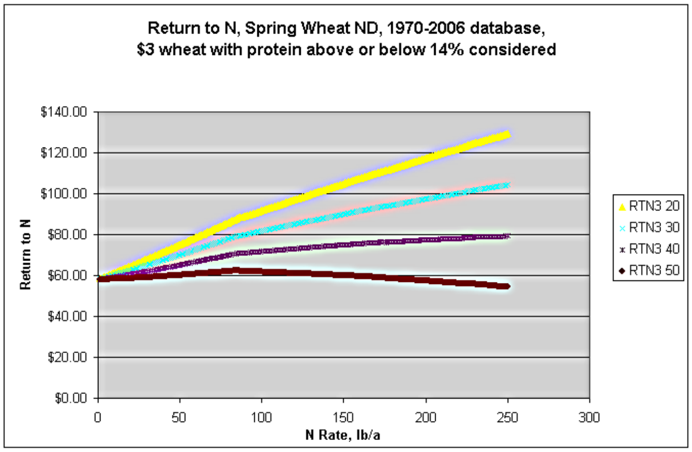

Figure 4. Return to N, 1970-2006 database, $3/bu spring wheat with protein above or below 14% considered.

For $3/bu wheat, even though the response to yield was linear, the curvilinear response of protein resulted in non-linear return to N. Maximum economic N rate for $0.50/lb N was about 90 lb N/a, however maximum N was not reached at lower N costs. The “crook” in each response line is the N rate at which there is no additional benefit for increasing protein at current elevator offerings to growers.

At $6/bu spring wheat, there is no maximum economic N rate for any of the considered N costs if figured on a statewide basis (Figure 5). N rate might be based on the ability of a grower to borrow money and the limit the grower might consider imposing to reduce lodging in over-fertilized grain. However, the statewide data suggest that even 250 lb N/a would not be over-fertilizing.

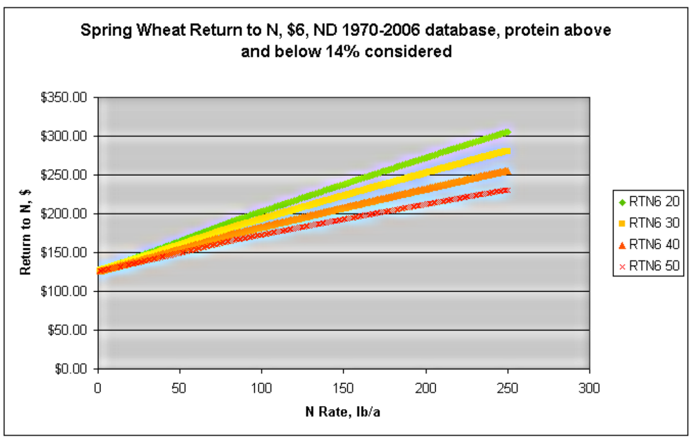

Figure 5. Return to N, 1970-2006 database, with $6/bu spring wheat, protein above and below 14% considered.

Recent experiences with N-calibration research for other crops (Franzen and Lukach, 2007; Franzen and Goos, 2007) have suggested that producing recommendations based on agriclimatology zones within North Dakota has merit. The state tends to be moister in the eastern third of the state. The state also has a locally cooler region in the northeast, centered in the

Langdon area. The west tends to be warmer and drier than the east. Because of these characteristics, recommendations for canola and malting barley have been segregated by region.

The archived and recent data was divided into region and analyzed for return to N separately. When these regionalized data were analyzed, the Langdon return to N for $3/bu spring wheat maximized return with $0.20 N at about 150 lb/a, and with $0.50 N at about 100 lb N/a (Figure 6). The Langdon area tends to be cooler by about 10 degrees F on any given day compared to Fargo, and organic matter content tends to be generally higher than other areas of the state, with 4-5% common in non-eroded soils. Using $6/bu spring wheat, the Langdon dataset maximized economic return at about 150 lb N for $0.20 N, and about 110 lb N for $0.50 N (Figure 7).

The eastern ND dataset for $3/bu wheat shows a linear positive return to N rate with $0.20 N, however maximum N rates were about 200 lb N at $0.30 N and about 175 lb N at $0.40 N. At $0.50 N, the maximum economic N rate was zero (Figure 8). With $6/bu wheat, return to N with N rate was a positive linear response at all N costs (Figure 9).

The western ND dataset for $3/bu wheat (Figure 10) also shows a linear positive return to N rate with $0.20 N and $0.30 N, with maximum return to N at $0.40 N of about 250 lb N/a, and $0.50 N of about 70 lb N/a. At $6/bu wheat (Figure 11), all N costs show a positive linear response.

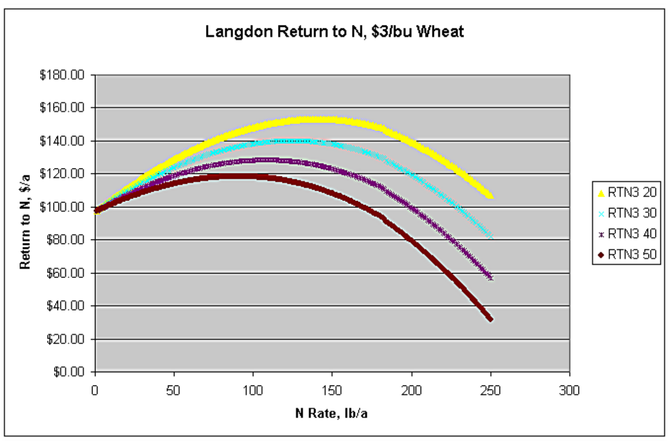

Figure 6. Return to N, Langdon and surrounding region dataset, $3/bu spring wheat.

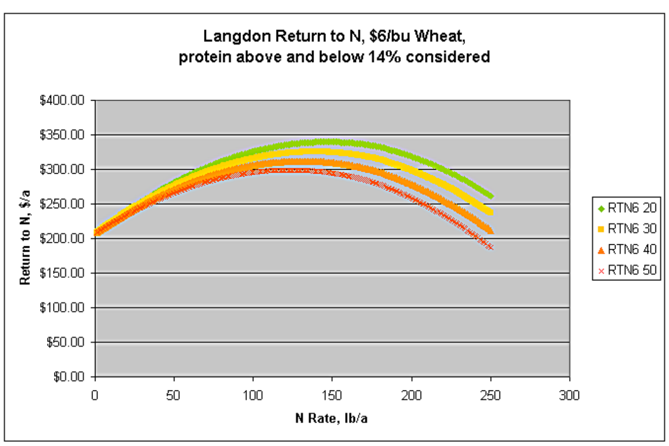

Figure 7. Return to N, Langdon and surrounding region dataset, $6/bu spring wheat.

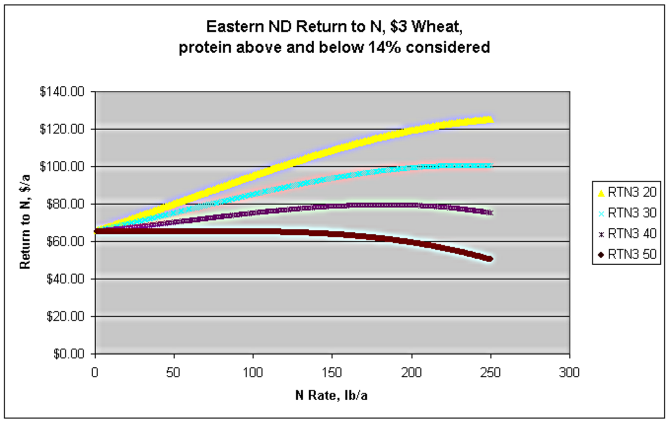

Figure 8. Return to N, Eastern ND less the Langdon region, $3 spring wheat.

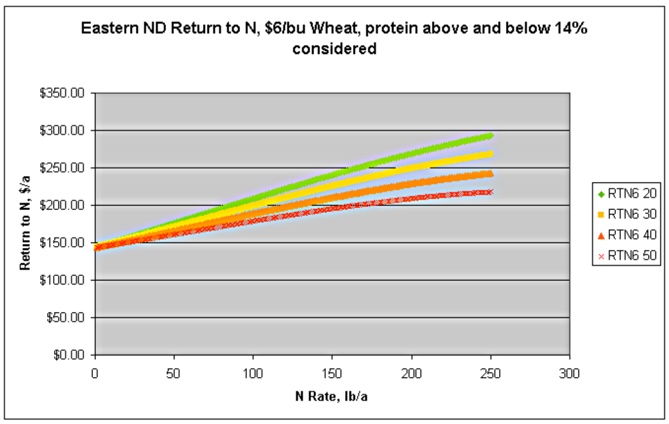

Figure 9. Return to N, Eastern ND less the Langdon region, $6 spring wheat.

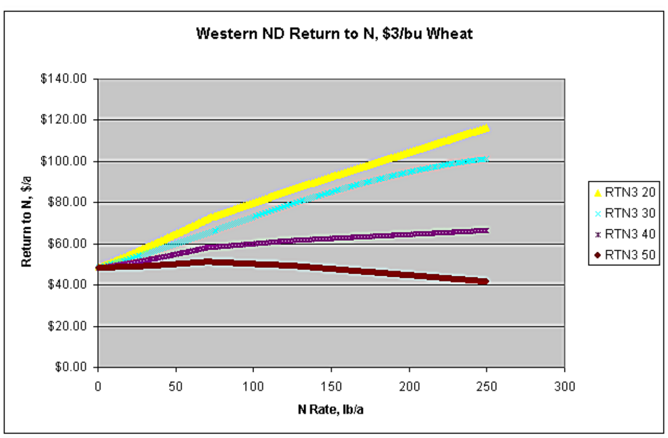

Figure 10. Return to N, western ND, $3 spring wheat.

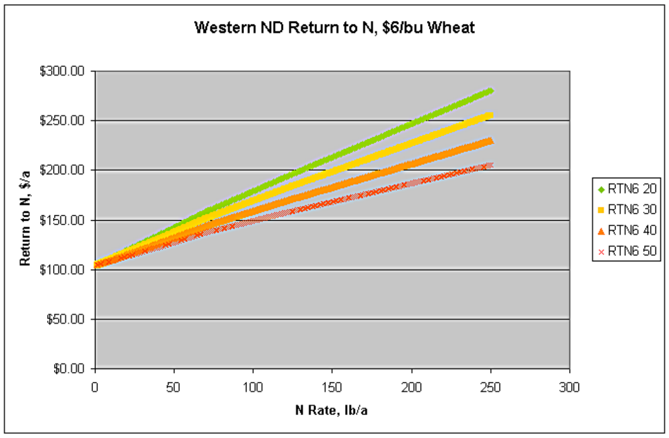

Figure 11. Return to N, western ND, $6spring wheat.

There are, at the time of the writing of this manuscript, only 13 site-years to relate any N mineralization indexes to yield response. Figure 12 shows the best relationship between the ISNT test, soil nitrate-N and organic matter to date. One might expect, if a relationship exists, that as ISNT test increases, the chance of yield increase with N would diminish. However, one might also expect that very low ISNT tests would reflect generally poorly productive soils, probably coarse in texture and low in organic matter. Soil nitrate-N would act to modify the effects of the ISNT test. As organic matter increases, yield increases might be expected to decrease. The relationship used in Figure 12 is only one of a many possible formulas that might be used to improve N recommendations as more data is gathered.

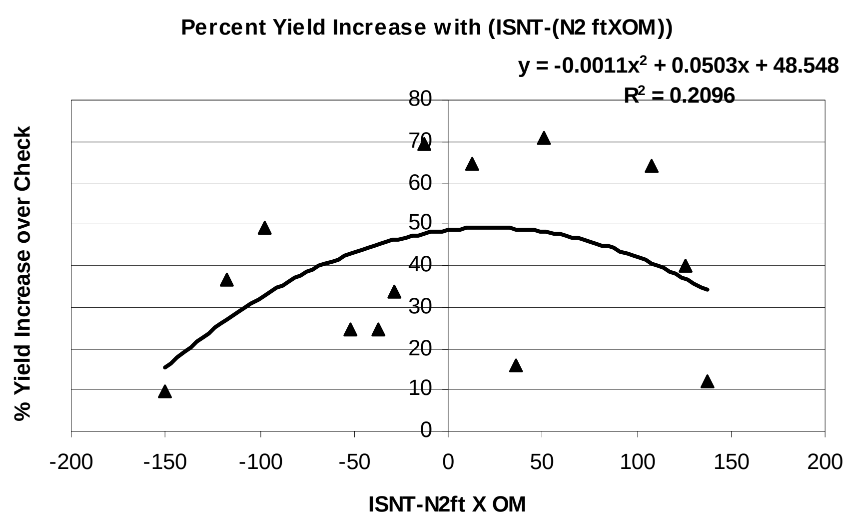

Figure 12. Recent N calibration field experiments relationships between ISNT test, soil test nitrate-N and organic matter.

Summary

Archived N calibration data from spring wheat/durum trials from 1970 to present were gathered, along with recent field N rate experiments since 2005. The results obtained to date suggest that our present N recommendations may not be adequate for current production and economic conditions. There appear to be good reasons for segregating North Dakota into agriclimatology zones. Response curves are different in different areas of the state. There also appears to be value in incorporating the ISNT test, organic matter or both into future recommendation formulas. A more extensive modern dataset will be needed to adequately formulate new recommendations for North Dakota wheat growers.

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Program Chair:

Greg Schwab
University of Kentucky
Lexington, KY
(859) 257-9780
gjschw2@uky.edu

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772 – 22nd Avenue South
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