2009 - Nitrogen Recommendation Recalibrations for Wheat in North Dakota
Final Report to IPNI
on the Nitrogen Recalibration for Spring Wheat and Durum for North Dakota Project

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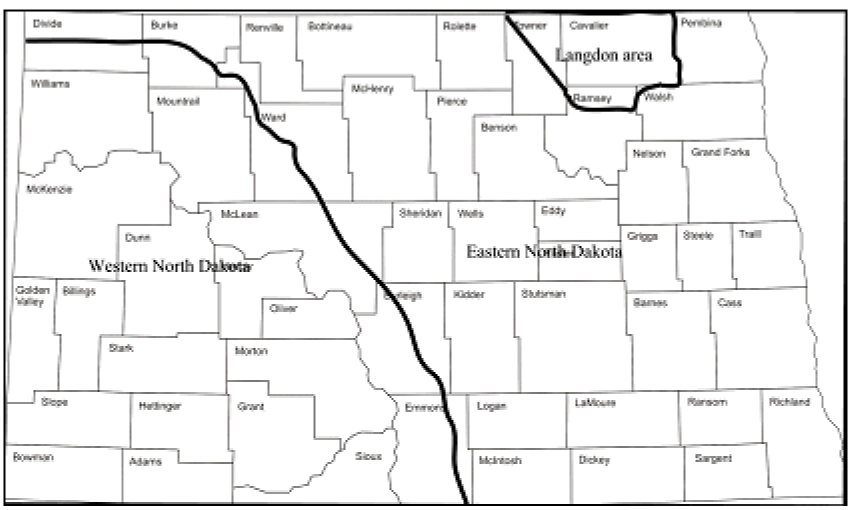
Executive Summary

The objective of this project was to review current N recommendations for wheat to determine profitable N recommendations for spring wheat and durum in North Dakota.

Over one hundred site-years of data were collected during this project from archived studies and recent N-rate studies. Soil test nitrate improved the relationship between available N and yield.

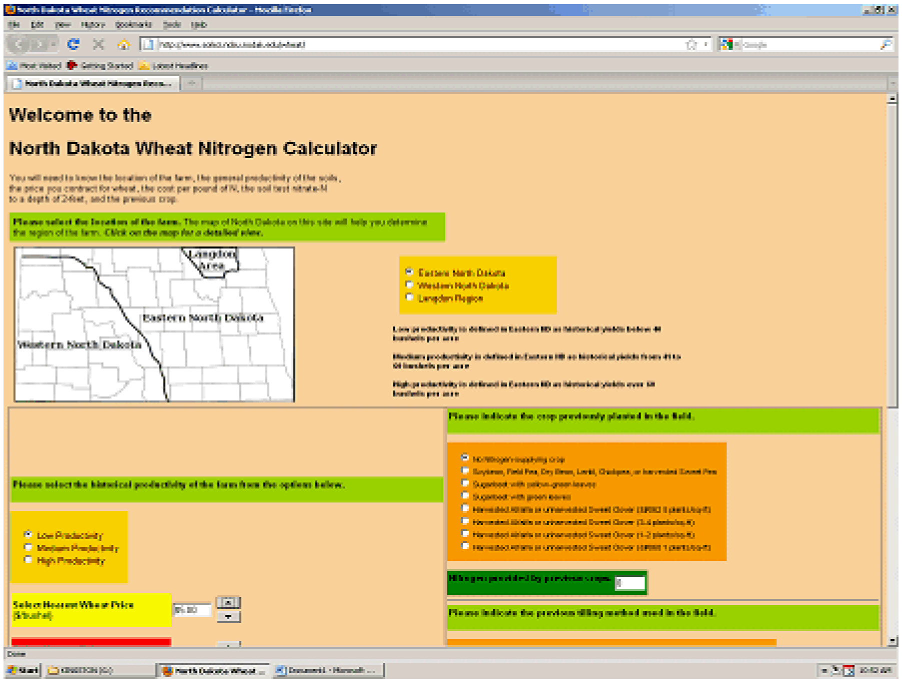
The Return to N approach (Sawyer and Nafziger, 2005) was used to establish relationships between yield/protein response and economics of N application. This approach was modified for wheat by adding the criteria for the protein relationship. In the economic analysis, a 50 cent per point premium was provided between 14-15% protein, and a 50 cent per point dockage for any protein below 14%.

The large number of sites made it possible to segregate different agri-climatology zones and determine whether the responses to available N were similar or different. The state was separated into the Langdon region, Eastern ND and Western ND.



Agri-climatology zones for North Dakota for use in spring wheat and durum N recommendations.

The grower is asked to look exclusively at past field yield history and select productivity levels of low, medium or high. The table values determined by region, productivity, wheat price and N cost are gross N requirements determined using return to N relationship equations. From this the soil test nitrate will be subtracted. Other adjustments include previous crop N credits, additions due to short-term no-till system, credit due to long-term no-till system, and organic matter if greater than 5.9%.



The opening segment of the North Dakota N Rate Calculator, available on the web at www.soilsci.ndsu.nodak.edu/franzen/franzen.html

The final recommendation is a fuzzy number, usually plus/minus 30 lb N/acre. Adjustment based on common sense of the grower/consultant and their experience with the field/field area will dictate the final rate. Consideration due to protein property of the wheat variety, N application techniques that might not be 100% efficient, excessive previous year straw and other considerations may play roles in defining the final rate.

The recommendations were made available December 1, 2009 in both print form (SF-712 revised) and as the web-based N Calculator. Thanks to the North Dakota Wheat Commission and the North Dakota SBARE-Wheat Committee, IPNI, Simplot, UAP, Georgia-Pacific and Tesserando-Kerley, for funding support in the years 2008 and 2009.

Complete Expanded Report

Final Report to North Dakota Wheat Commission on the Nitrogen Recalibration for Spring Wheat and Durum for North Dakota Project

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Additional collaborators-
Gregory Endres, Area Agronomist, Carrington Research and Extension Center
John Lukach, Langdon Research and Extension Center
Roger Ashley, Dickinson Research and Extension Center
James Staricka, Williston Research and Extension Center

The objective of this project was to review current N recommendations for wheat in light of archived N-rate data and newly generated data to determine profitable N recommendations for spring wheat and durum for North Dakota growers.

Over one hundred site-years of data have been collected during this project. About one half of the data comes from archived studies since 1970. The other one half of the data comes from N-rate studies conducted from 2005-2009. Over 500 data points have been used to establish relationships between available N and wheat yield/protein.

One of the first relationships to be challenged after accumulating this data was to review the value of a soil test nitrate value towards better recommendations.

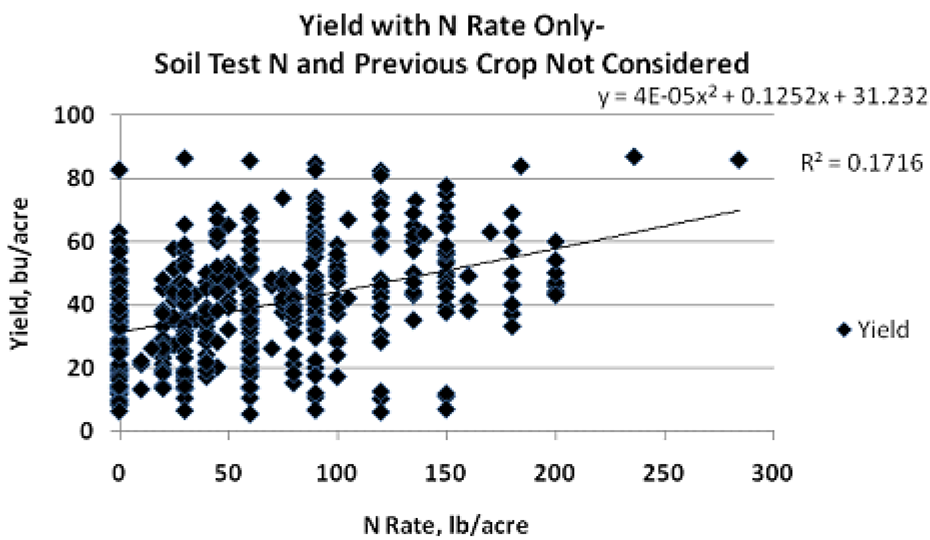

Figure 1. Relationship of spring wheat/durum yield with N rate, without regard for soil test nitrate.

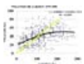

Figure 2. Relationship of spring wheat/durum yield with available-N, including soil test nitrate. The straight line going through 0, 0 is the current N recommendations.

Without soil test nitrate, the relationship becomes a straight line, which is not a normal soil fertility and crop yield relationship (Figure 1). The r^2 is relatively low. The scatter of points is great. With soil test nitrate (Figure 2), the response is curvilinear and typical of soil fertility and crop growth relationships, and the r^2 is higher with soil test nitrate than without.

Several methods to interpret the data relationships were used, including a simple regression relationship- optimal yield/protein; delta yield (an approach using the relationship of potential increase in a plot over the check plot); and return to N.
The Return to N approach was advanced by a consortium of soil fertility scientists led by Iowa State and Illinois (Sawyer and Nafziger, 2005). The approach uses the following steps to determine the economic optimal rate of N (or maximum return to N):

1. Generate the mathematical relationship between yield and N rate or available N.
2. Predict yield at each pound of N between 0 and a reasonable maximum rate of N.
3. Determine the economic return from a range of crop prices and N costs.
4. For each crop price, determine the economic optimal rate of N for each increment of N cost.

This approach was modified for wheat by adding the criteria for the protein relationship. In the economic analysis, a 50 cent per point premium was provided between 14-15% protein, and a 50 cent per point dockage for any protein below 14%.

The large number of sites made it possible to segregate different agri-climatology zones and determine whether the responses to available N were similar or different. Figures 3-5 illustrate that the return to N relationships are very different for the three zones selected, and so recommendations are different for each of the three zones.

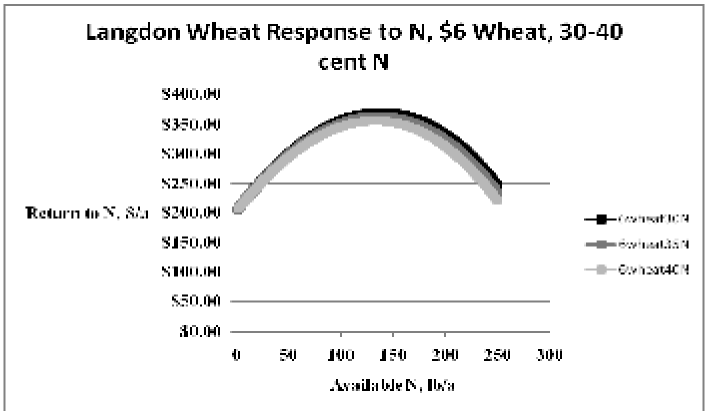

Figure 3. Return to N for Langdon region at $6/bushel wheat.

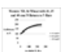

Figure 4. Return to N for Western region at $6/bushel wheat.

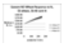

Figure 5. Return to N for Eastern region at $6/bushel wheat.

The three agri-climatology zones are described in Figure 6.

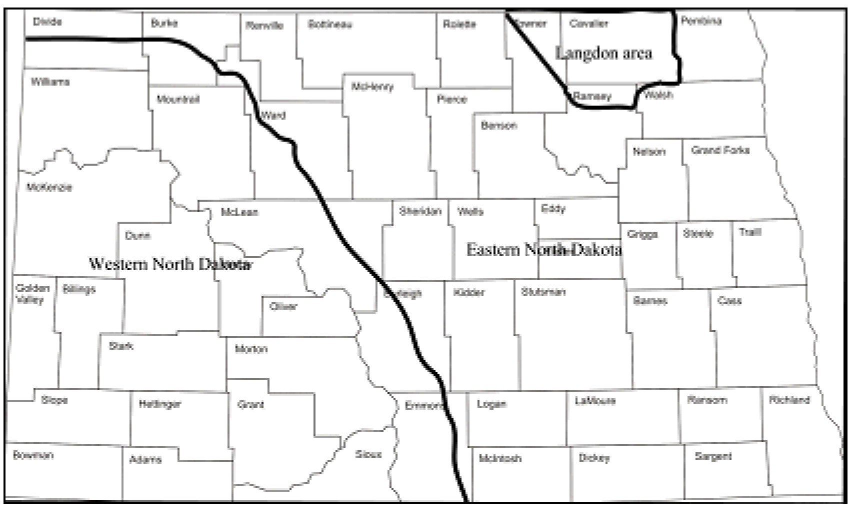

Figure 6. Agri-climatology zones for North Dakota for use in spring wheat and durum N recommendations.

Previous recommendations forced growers and their consultants to predict future yield to determine that years' N rate. This prediction prompt was one reason for less than adequate N rates in some years. The newly constructed recommendations prompt the grower/consultant to look in the past at the historic productivity of the field/part of field and select one of three productivity ranges on which to base recommendations- low, medium and high. These are defined below:

Langdon and Eastern North Dakota-

Low= yields 40 bu/acre or less
Medium = yields from 41-60 bu/acre
High = yields greater than 60 bu/acre

Western North Dakota

Low = yields 30 bu/acre or less
Medium = yields from 31-50 bu/acre
High = yields above 50 bu/acre

Based on the yield/protein and available N relationships, and the economics determined from the return to N relationships determined for each whole $ of wheat price, the following tables were developed to determine table profitability optimum N rates for each region-

Table 1. Langdon Region Low Productivity (<40 bu/acre)

	N Cost cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	------------------Gross Optimal N ----------------------								
$3.00	100	90	80	70	60	50	40	30	20
$4.00	110	100	90	80	70	60	50	40	30
$5.00	120	110	100	90	80	70	60	50	40
$6.00	120	115	110	100	90	80	75	65	60
$7.00	120	115	110	100	95	90	80	75	70
$8.00	120	115	110	105	95	90	85	80	75
$9.00	120	115	110	105	100	95	90	85	80
$10.00	120	115	110	110	105	100	95	90	85

Table2. Langdon Region Medium Productivity (41-60 bu/acre)

	N Cost cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	------------------Gross Optimal N ----------------------								
$3.00	130	125	120	115	110	100	80	50	20
$4.00	135	130	125	120	115	100	90	80	70
$5.00	140	135	130	125	120	115	100	90	80
$6.00	140	135	130	125	120	115	105	95	85
$7.00	140	135	130	125	120	115	110	100	85
$8.00	140	135	130	130	125	120	115	105	85
$9.00	140	135	135	130	125	120	115	110	95
$10.00	140	135	135	130	125	120	115	110	100

Table 3. Langdon Region High Productivity (>60 bu/acre)									
	N Cost cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	-------------------Gross Optimal N ----------------------								
$3.00	160	145	130	125	110	100	90	75	40
$4.00	160	150	140	130	120	110	100	90	80
$5.00	160	155	150	140	130	120	115	105	100
$6.00	160	155	150	140	135	125	120	116	110
$7.00	160	155	150	145	135	130	125	120	115
$8.00	160	155	150	145	140	135	130	125	120
$9.00	160	155	150	145	140	135	130	130	125
$10.00	160	155	150	145	140	140	135	135	130

Table 4. Eastern North Dakota Low Productivity (<40 bu/acre)									
	N Cost cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	------------------------------------Gross Optimal N --								
$3.00	75	70	60	50	25	0	0	0	0
$4.00	80	75	70	60	50	40	30	20	0
$5.00	100	90	80	70	60	50	40	30	20
$6.00	125	120	115	110	105	100	90	80	70
$7.00	140	130	120	115	110	105	95	85	75
$8.00	150	140	130	120	115	110	105	100	95
$9.00	155	150	145	140	135	130	125	120	115
$10.00	160	155	150	145	140	135	130	125	120

Table5. Eastern North Dakota Medium Productivity (41-60 bu/acre)									
	N Cost cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	-----------------Gross Optimal N ---------------------								
$3.00	125	115	105	90	60	30	0	0	0
$4.00	150	140	130	120	110	100	80	50	0
$5.00	160	150	140	130	120	110	100	90	80
$6.00	170	160	150	140	130	120	110	100	90
$7.00	180	170	160	150	140	130	120	110	100
$8.00	185	175	170	165	160	150	140	130	120
$9.00	190	180	175	170	165	160	150	140	130
$10.00	200	190	185	180	170	165	160	150	140

Table 6. Eastern North Dakota High Productivity (>60 bu/acre)									
	N Cost cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	--------------------Gross Optimal N -----------------------								
$3.00	250	190	175	150	125	60	0	0	0
$4.00	250	235	220	200	180	160	120	100	0
$5.00	250	235	220	200	190	180	160	140	120
$6.00	250	250	225	210	200	190	180	160	150
$7.00	250	250	250	240	220	200	190	180	175
$8.00	250	250	250	250	225	210	200	190	180
$9.00	250	250	250	250	250	220	210	200	190
$10.00	250	250	250	250	250	240	230	220	200

Table 7. Western North Dakota Low Productivity (<30 bu/acre)									
	N Cost cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	--------------------Gross Optimal N ------------------------								
$3.00	100	80	70	60	50	45	40	0	0
$4.00	105	95	85	75	65	55	45	30	0
$5.00	110	100	90	90	70	60	50	40	30
$6.00	115	110	110	105	95	90	85	80	60
$7.00	115	110	115	105	95	90	85	80	60
$8.00	115	110	115	105	95	90	85	80	60
$9.00	115	110	120	105	95	90	85	80	60
$10.00	115	110	120	105	95	90	85	80	60

Table8. Western North Dakota Medium Productivity (31-50 bu/acre)									
	N Costs cents per pound N								
Wheat price	20	30	40	50	60	70	80	90	100
	---------------------Gross Optimal N ------------------------								
$3.00	125	120	110	100	90	80	60	0	0
$4.00	125	125	120	110	100	90	80	70	50
$5.00	130	130	125	120	110	100	90	80	70
$6.00	135	135	130	125	120	110	100	95	90
$7.00	140	135	130	125	120	110	100	95	90
$8.00	140	135	130	125	120	110	100	95	90
$9.00	140	135	130	125	120	110	100	95	90
$10.00	140	135	130	125	120	110	100	95	90

Table 9. Western North Dakota High Productivity (>50 bu/acre)									
	N Costs cents per pound N								
Wheat price	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	--------------------Gross Optimal N ------------------------								
$3.00	175	170	160	150	140	130	110	50	0
$4.00	175	175	170	160	150	140	130	120	100
$5.00	180	180	175	170	160	150	140	130	120
$6.00	185	185	180	175	170	160	150	145	140
$7.00	190	185	180	175	170	160	150	145	140
$8.00	190	185	180	175	170	160	150	145	140
$9.00	190	185	180	175	170	160	150	145	140
$10.00	190	185	180	175	170	160	150	145	140

The table values determined by region, productivity, wheat price and N cost are gross N requirements. From this the soil test nitrate will be subtracted. Other adjustments were investigated, including effects of tillage.
No-till wheat growers have related for years that once they were in continuous no-till for over 5 years, they could often reduce their N levels. A significant number of long-term no-till wheat growers regularly reduce their N rates compared to published recommendations. Since we had many sites, and most of their tillage treatments were defined, continuous no-till (pure no-till and shallow one-pass seeding) sites were segregated from conventional sites. The following relationships illustrated in Figures 7-9 formed the basis for the continuous no-till N credit adjustment.

A 50 bu/acre conventional yield required about 200 lb N/acre, while a 50 bu/acre no-till yield required about 140 lb N/acre (Figure 7).

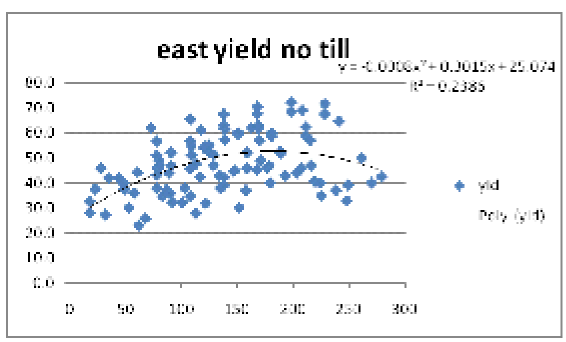

Figure 7. The relationship between yield (y axis) and available N (x axis) for conventional and no-till sites.

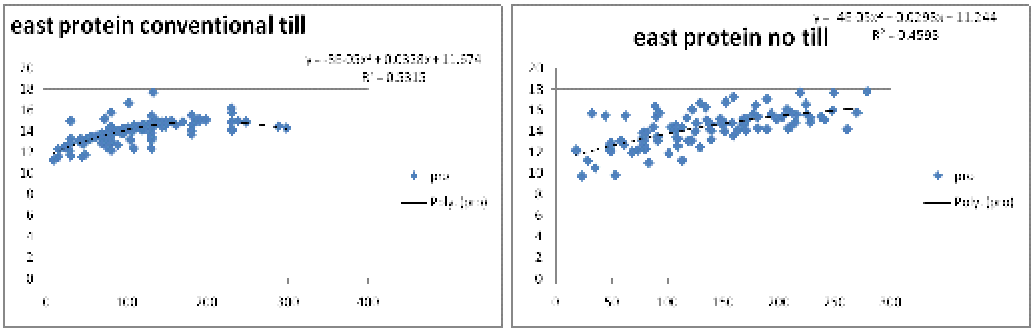

Figure 8. The relationship between protein (y axis) and available N (x axis) for conventional and no-till sites.

To achieve a protein of 15% in conventional till sites required about 220 lb N/acre. In no-till sites, 15% protein was reached with about 150 lb N/acre.

Figure 9. The return to N relationships for conventional till and no-till sites at $5/bushel wheat. Conventional till site maximized return to N at available N of from 220-250 lb N/acre. Return to N for no-till sites was maximized for $5/bushel wheat at available N of from 150-170 lb N/acre.

Using these data as support, there is a 50 lb N/acre credit for continuous no-till of greater than 5 years.

Conversely, observations outside of this study support an additional 20 lb N/acre requirement for fields with 5 years or less in continuous no-till. No-till is defined as the "pure" no-till of a narrow seeding slit, but also includes shallow (3 inches or less in depth) one-pass seeding. If during the no-till rotation the soil is broken up by a tillage outside of the definition above, the field goes back to year 1. A number of studies, including some in North Dakota show that a single year of deeper tillage destroys the work of many years in terms of soil biology, structure and other related properties.

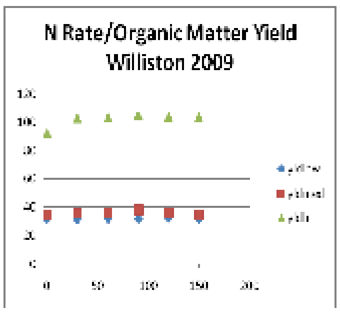

Figure 10. 2009 N rate studies at Valley City, Carrington, Langdon, Williston and Dickinson. N rate studies were conducted in a single field at each location at a low, medium and high organic matter area within the field.

In 2009, studies were conducted at five locations where N rate experiments were established at three sites within a single field varying with three different levels of surface organic matter. The results showed that organic matter, at least up to organic matter of 5.9% contributed to higher productivity within the field, but did not change the N response relationship. Therefore, there is no organic matter adjustment in the new recommendations for organic matter levels below 6%. Additional observations within the study showed that higher levels of organic matter did not contribute to higher productivity, but certainly release more N for use by crops. Additional N release from higher organic matter sites may result in pre-anthesis lodging. Therefore, there is a 50 lb N credit for each whole organic matter % higher than 5%.

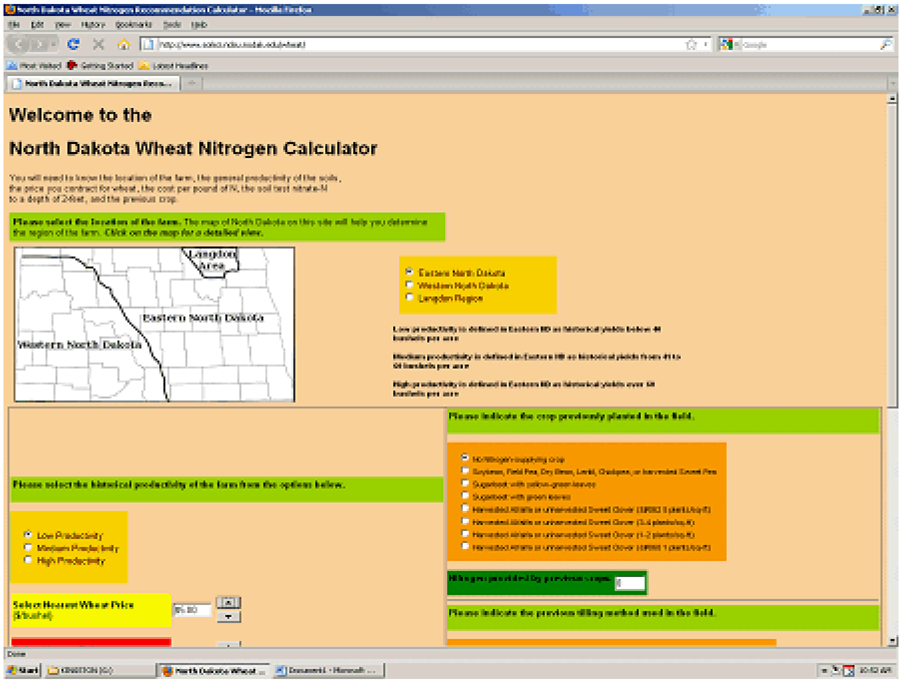

Figure 11. The opening segment of the North Dakota N Rate Calculator, available on the web at **www.soilsci.ndsu.nodak.edu/franzen/franzen.html**

Previous crop credits already defined are subtracted.
The final recommendation is a fuzzy number, usually plus/minus 30 lb N/acre. Adjustment based on common sense of the grower/consultant and their experience with the field/field area will dictate the final rate. Consideration due to protein property of the wheat variety, N application techniques that might not be 100% efficient, excessive previous year straw and other considerations may play roles in defining the final rate.

The recommendations were made available December 1, 2009 in both print form (SF-712 revised) and as the web-based N Calculator illustrated previously. Feedback from the new recommendations has been positive from growers, consultants and USDA-NRCS.

Sincere thanks to the North Dakota Wheat Commission and the North Dakota SBARE-Wheat Committee for their support of this project. Additional funds were secured during portions of the project through IPNI, Simplot, UAP, Georgia-Pacific and Tesserando-Kerley, for funding support for this project.