NORTH DAKOTA CORN RECOMMENDATIONS FOR PREPLANT AND SENSOR DIRECTED SIDEDRESS N

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Introduction

Nitrogen rates for preplant N application in North Dakota have been drastically revised. The former yield-based strategy may have served when N costs were stable and relatively low and high yields in North Dakota were rarely higher than 100 bushels per acre. Due to improved germplasm developed at North Dakota State University and other northern Land-Grant Universities with favorable adaptation to North Dakota climate and soil conditions corn has become one of the most planted crops in the state. Economic conditions have resulted in growth within the last twenty years from about 300,000 acres in the southeastern counties of the state in 1970 to 3.9 million acres in 2013 (USDA-NASS, 2013), with nearly every county represented by significant corn acreage. Nitrogen prices over the past ten years have remained high, and prices obtained by corn growers for their crop have been much more volatile than in the previous corn-growing history of the USA.

Sawyer and Nafziger (2005) introduced a corn N rate recommendation strategy based on an economic production function; the N rate is based on empirically generated yield response due to N rate, while considering the economic return from each increment of N applied less the cost of N. This return to N strategy is now used by most central USA corn-belt states. Most of the states have not based their N recommendations on unique soil properties that might modify the N recommendation. However, in North Dakota, the return to N relationship for spring wheat and durum production was improved by separating the state into three regional categories due to climate and N supplying capability of soils.

The preplant N recommendations are the result of 117 site-years of corn N-rate data from North Dakota and the immediately surrounding region collected during the past 10 years. The data indicated that separate recommendations were necessary for the region west of the Missouri River. In eastern North Dakota, recommendations for long-term no-till N are different than those for conventional till fields. Conventional till fields are divided into those with high clay surface texture in a low and high productivity category and medium textured fields with low and high productivity. Low productivity fields in eastern North Dakota are usually low due to N losses from leaching or denitrification. Side-dress N rate determination up until present has mostly been an educated guess. While conducting N rate trials, 60 sites were sensed at V6 and V12 using both the Holland Crop Circle sensor and the GreenSeeker sensor. Algorithms have been developed for N recommendation categories for use in directing side-dress application. Red NDVI algorithms were effective in predicting yield at V6 using both sensors, while the Red Edge NDVI algorithms were most effective in predicting yield both at V6 and V12. Most side-dress in North Dakota will be conducted about V6.

Materials and Methods

Seventy-seven N rate trials were conducted in North Dakota from 2010 to 2013. An additional 40 N rate trials from southern Manitoba, northwest Minnesota and northern South Dakota were tested for compatibility with the North Dakota data sets and included in the final recommendation analysis. The N rate trials in North Dakota were nearly all established in grower fields using their hybrid choices and their planting and management skills. Each experiment was a randomized complete block with six N treatments (check, 40, 80, 120, 160 and 200 lb N per acre) and four replications. Fertilizer N source was ammonium nitrate applied preplant within about one week of planting. Each experimental unit was 20 feet long and 10 feet wide. One row the length of the plot was hand harvested, then shelled for yield determination. Regression analysis and multiple regression analysis were conducted using Excel 2007.

Results and Discussion

To determine whether soils or region impacted the relationship of N to corn yield, a multiple regression analysis was used to determine which characteristics of the sites tended to categorize the experiments in a more meaningful manner. The results of the exercise indicated that sites west of the Missouri river have a different response curve compared to eastern sites. In the east, medium textured soils should be analyzed separately compared to high clay soils, and long-term no-till sites (those sites that have been in continuous no-till greater than six years) should be analyzed separately from the rest of the medium textured soils. There are typically few fields with dominant high clay soils that are being managed using a long-term no-till system in North Dakota. No-till soils were previously found to require less N for similar yield and protein compared to conventional tillage in wheat (Franzen, 2009). Many long-term no-till fields continue to increase in organic matter content, so release of N from long-term no-till soils is not a logical reason for the lower N rate required in these soils; rather a likely explanation is increased N use efficiency of long-term no-till soils. Soil biological activity is much higher in long-term no-till fields (Awale et al., 2013). Free N may be rapidly taken up by microbes and transformed through biological processes into intermediate organic N compounds which are then released into a kind of natural slow-release N fertilizer.

Since North Dakota has historically incorporated the soil test nitrate to 2-feet in depth into N recommendations for all of its crops, it was logical to again investigate whether its use in corn was relevant. Figure 1a shows the relationship of corn yield with applied N treatments with no regard for soil nitrate or previous crop credits, which were mostly soybeans, in the medium-textured soils within the project. Medium –textured soils include sandy loams, loams, and fine sandy loams.

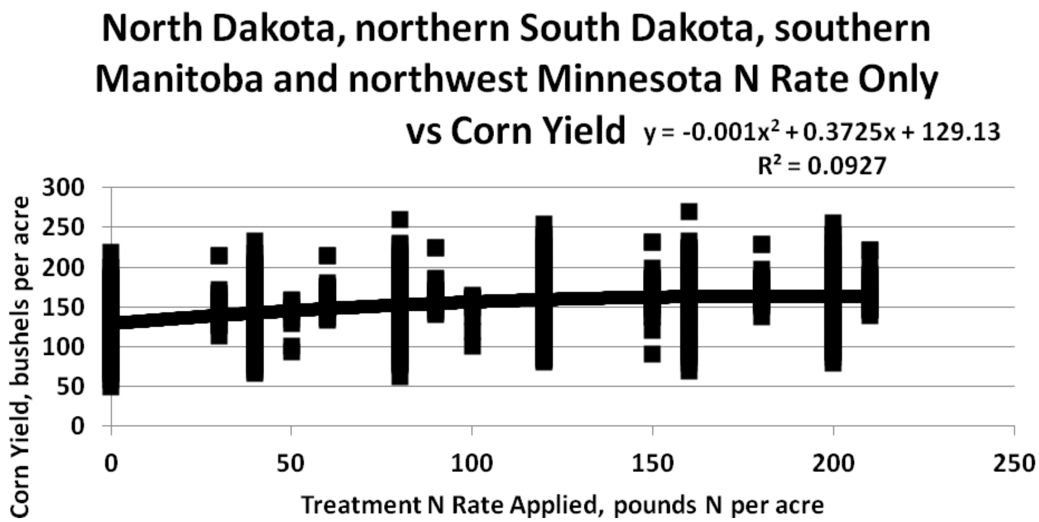

Figure 1a. Relationship between N treatment rate only and corn yield for all 117 sites in North Dakota, northern South Dakota, northwest Minnesota, and southern Manitoba.

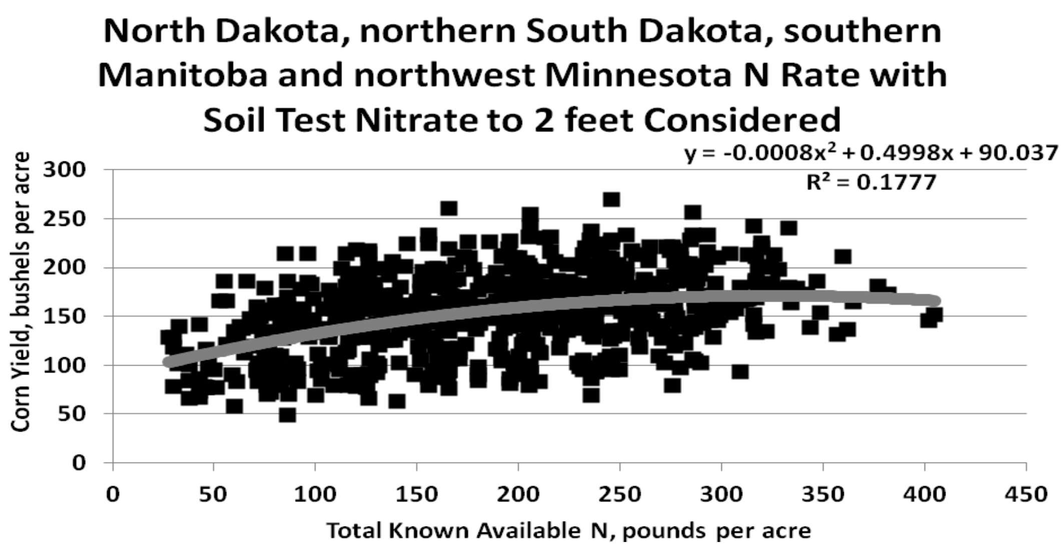

Figure 1b. Relationship between total known available N and corn yield for North Dakota, northern South Dakota, southern Manitoba, northwest Minnesota and corn yield. Total known available N includes soil test nitrate to 2-feet in depth, N treatment rate and previous crop credit.

Including soil test nitrate to 2-feet in depth explains the yield and N relationship much better than N treatment rate alone (Figure 1b). The R^2 relationship of 0.18 is not great, but it much exceeds the 0.09 R^2 without soil test N. In addition, it is difficult to explain the tremendous range in yield with N rate only at the zero N rate. Including soil test N removes yields above 150 bushels per acre from the left side of Figure 1b.

Figure 2 represents the return to N relationship derived from the current data base of medium texture sites between an N cost of 20 cents per pound of N and $1 per pound of N, and corn prices from $3 to $8 per bushel. There are some important observations from most of the return to N figures. First, corn price makes the most difference in terms of economic return to the grower compared to N cost. At N costs above $3 per bushel, N rates greater than 100 pounds per acre are required to provide the greatest economic return in medium textured soils. The second point is that at higher corn prices, there is a limit to the N rate that achieves maximum economic return. In the medium texture sites, N rates even at $8 per bushel corn prices should not exceed about 240 lb N per acre if maximum economic return was the goal. This rate includes the soil test N and any previous crop credits in the field.

A multiple regression of site categories of west-river, eastern long-term no-till, eastern high clay sites with higher yield potential, eastern high clay sites with lower yield potential, eastern medium texture conventional till sites with high yield potential and eastern medium texture sites with lower yield potential segregated from each other. The relationships between total known available N and yield are shown in Fig. 3 through Fig. 11. Of particular interest are the lower yield potential medium textured sites in Fig. 7 and the lower yield potential high clay sites in Fig. 11. The shape of the response curve suggests that very high rates of N are required in these soils to achieve higher yields.

The new North Dakota corn N recommendations are published in Franzen, 2014a. Must growers and crop consultants will utilize the North Dakota Corn Nitrogen Calculator to determine preplant N rate.

http://www.ndsu.edu/fileadmin/soils/pdfs/cornsf722.pdf

The solution for more efficient N strategies cannot be rate, but it must include timing. For this reason, the revised N recommendations for North Dakota strongly urge growers to split apply N and apply a nitrification inhibitor to any preplant N application in the low productivity medium texture and high clay categories. The list of algorithms for use in V6 and V12 growth stages are published in Franzen et al. (2014b).

To use the active-optical sensors, an N-unlimiting area will be established when the base preplant N rate is applied preplant within soil category within intended hybrid. At side-dress, the applicator will enter the field with the appropriate algorithm programmed into the controlling software and run the sensor through the N-unlimiting area. The reading will establish the highest yield possible for the conditions. Once this standard is established, the applicator begins to operate in the rest of the field. If the reading is within 5% of the standard, no N is applied, as the highest yield possible with N rate is already likely. If the reading is more than 5% less than the standard the controller will calculate the yield difference, multiply times percent N in the grain and divide by an efficiency factor, which if subsurface application would be about 0.6. If the reading is below the minimum associated with the algorithm no N is applied, since a below minimum reading indicates that there is a low stand count or another condition unrelated to N. The algorithms and a deeper explanation of them is in Franzen 2014b http://www.ndsu.edu/fileadmin/soils/pdfs/sf1176-5.pdf .

The side-dress algorithms are meant as a starting point for growers. Work is proceeding on a 'machine learning algorithm' for use by growers to morph the original algorithm into their own personal algorithm. When the grower applies a side-dress operation, no N will be applied during a sensing pass. When the field is harvested, the grower has sensor readings associated with yield, similar to the data acquired in each N-rate trial that was used to develop the original algorithm. As the grower continues to add yield/sensor reading data into the weighted original algorithm, a new personal algorithm will develop. The precision ag business infrastructure will have to be developed to support these new tools.

Summary

The revised North Dakota N recommendations for corn include regional, soil and tillage system recommendations specifically for west-river fields, eastern medium-texture soils, high clay soils and fields under long-term no-till management systems. The recommendations are based on return to N economic production functions. In high clay soils, split application of N are strongly encouraged, with side-dress N application rate based on the use of an active-optical sensor and algorithms developed to support the N rate. The side-dress N algorithms are meant as a first step grower use. Work is proceeding on a learning algorithm growers can use to morph the published algorithm into their personal farm algorithm. Increased grower use of these algorithms will require greater support by companies supplying sensors to growers and custom applicators, and use of the algorithms and the development of grower algorithms will require development of precision ag business infrastructure to support their use.

Acknowledgements

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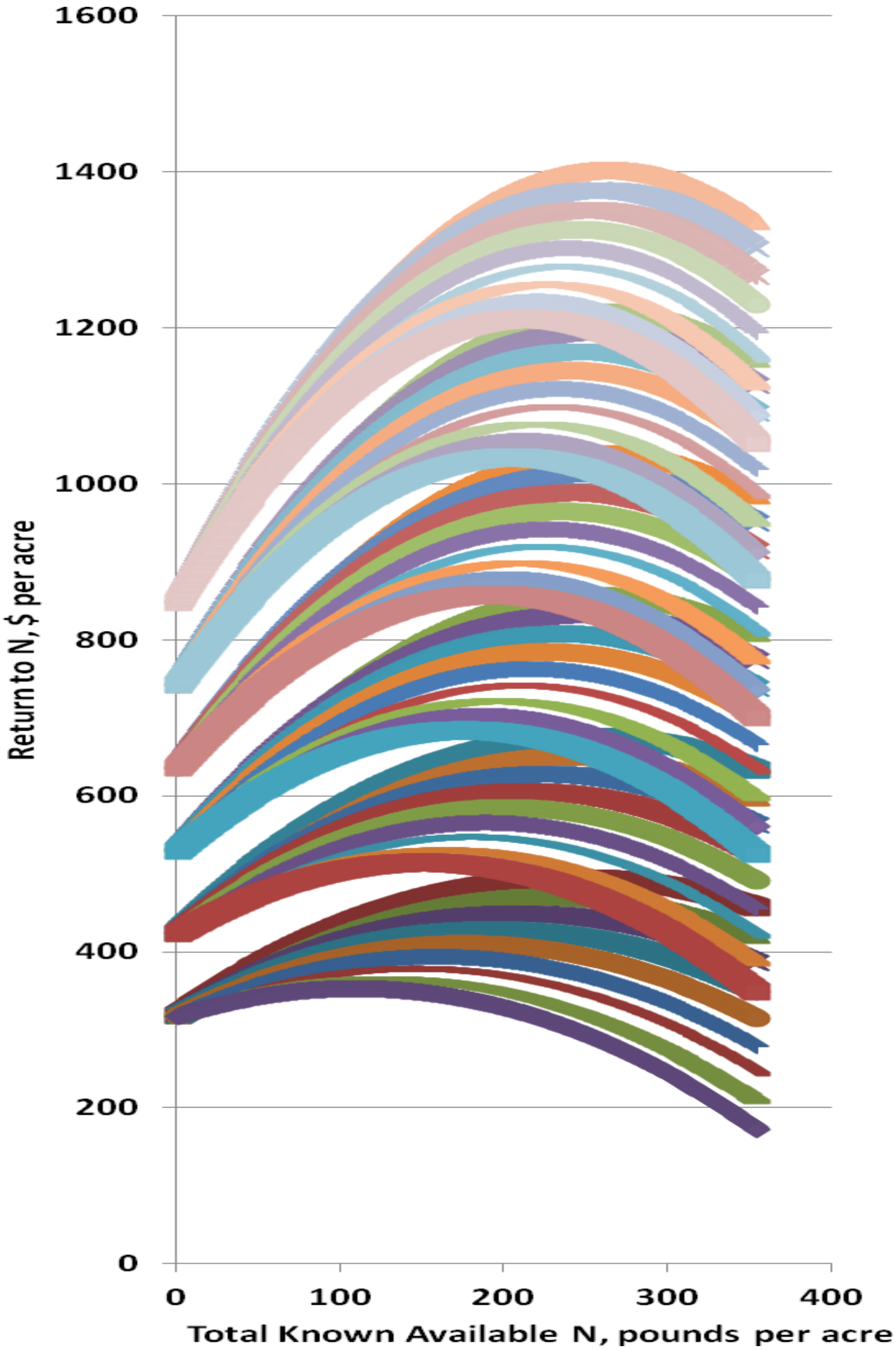

Figure 2. Return to N for N costs from 20 cents per pound of N to $1 per pound of N and corn prices between $3 per bushel and $8 per bushel. Bottom group of curves represents $3 corn price. Top group of curves represents $8 corn price. Within each group, the bottom curve represents $1 per pound of N, with each progressive curve representing a 10 cent decrease in price, with the upper curve within each group representing 20 cent N ($328 per ton anhydrous ammonia cost).

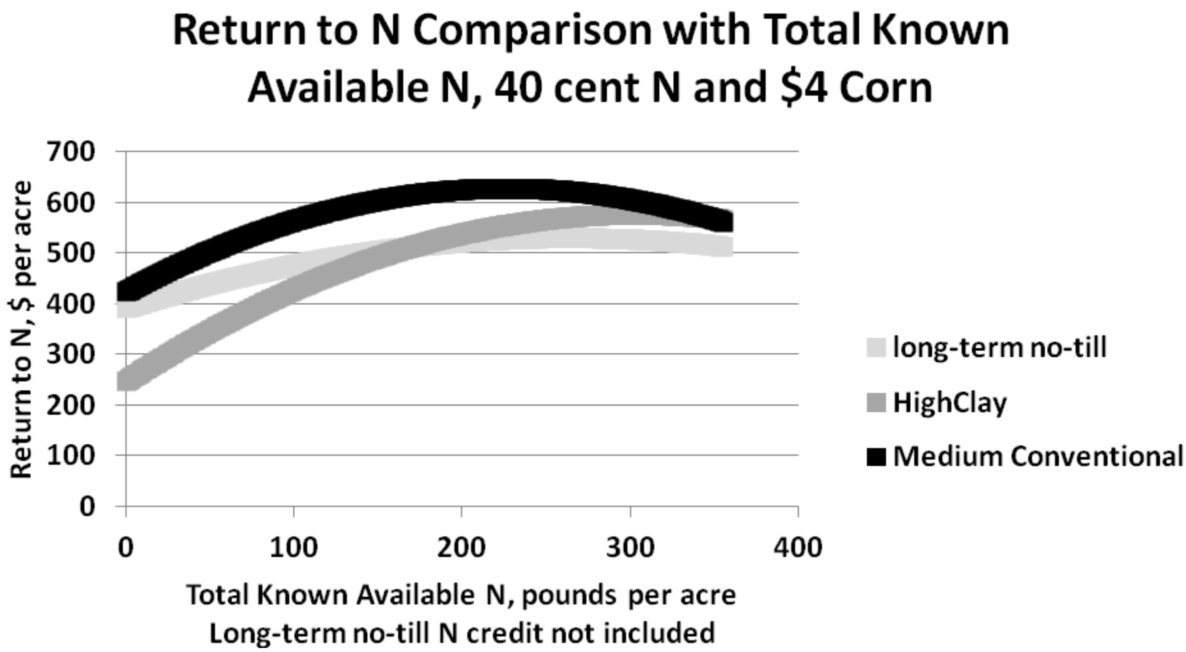

Figure 3. Return to N comparison to illustrate the differences in response curves between high clay sites, medium textured conventional sites and long-term no-till sites in North Dakota.

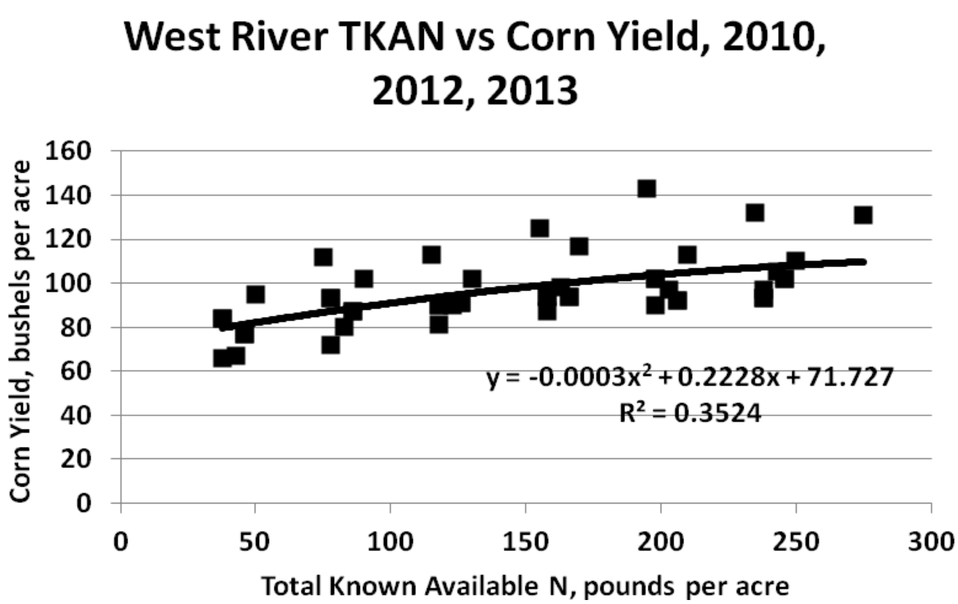

Figure 4. Response of corn in the North Dakota sites west of the Missouri River. All long-term no-till.

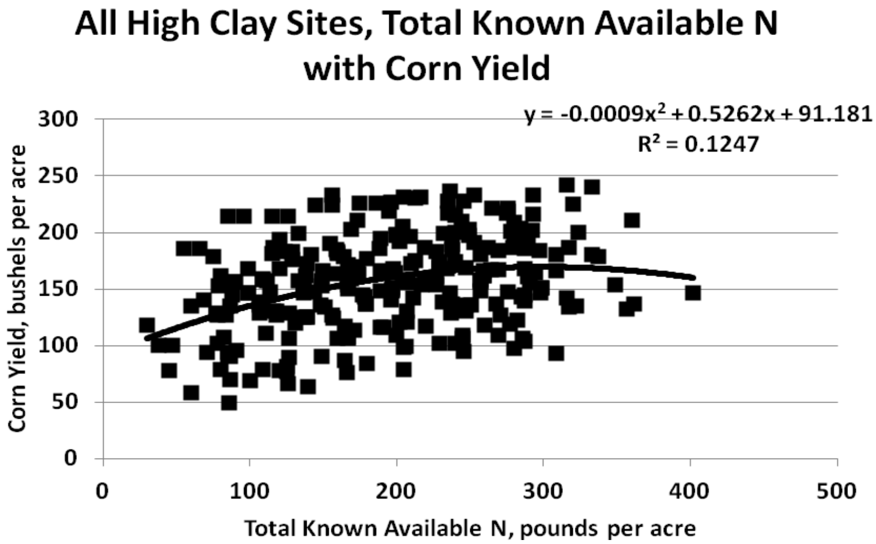

Figure 5. Response of corn to N in high clay soils.

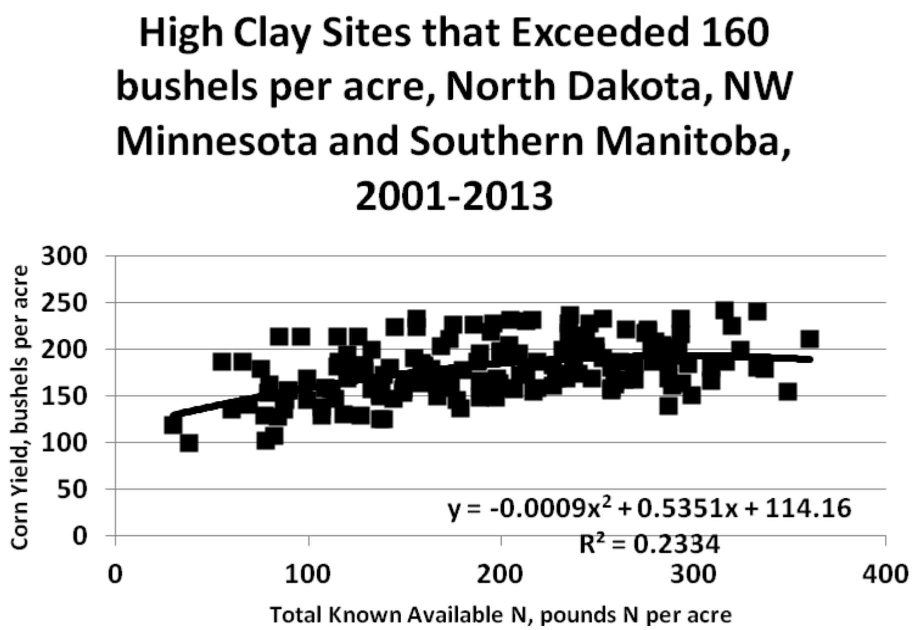

Figure 6. Response of corn to N in high clay soils with yields greater than 160 bushels per acre.

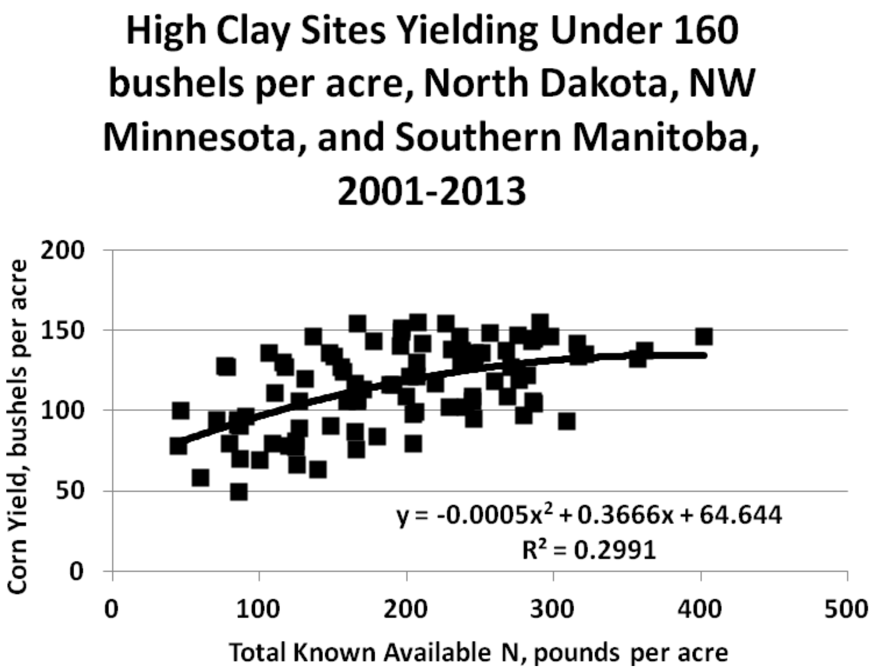

Figure 7. Response of corn to N in high clay soils with yields not exceeding 160 bushels per acre.

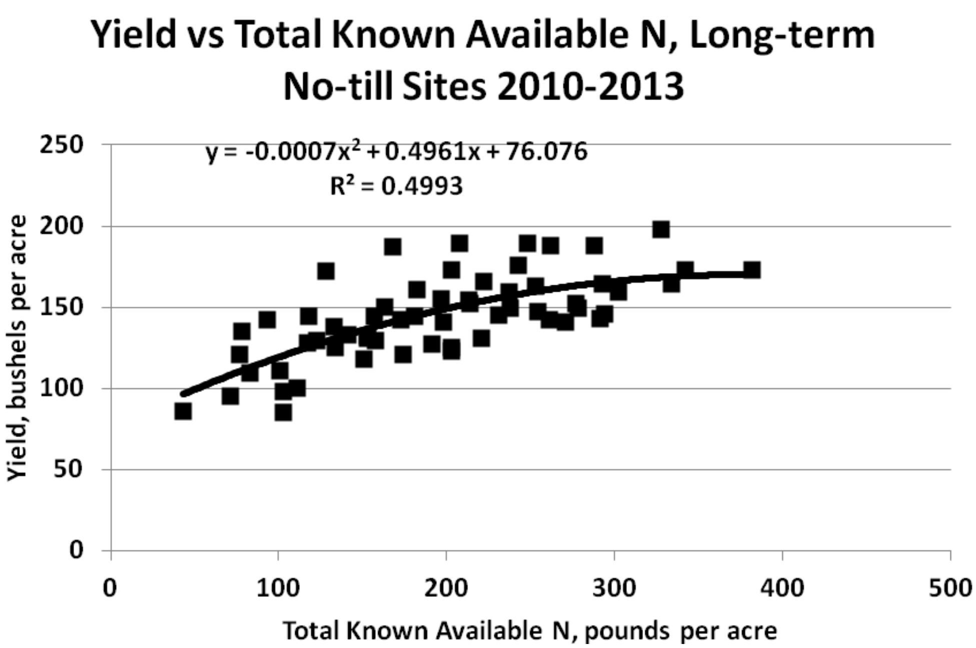

Figure 8. Response of corn to total known available N, all long-term no-till sites.

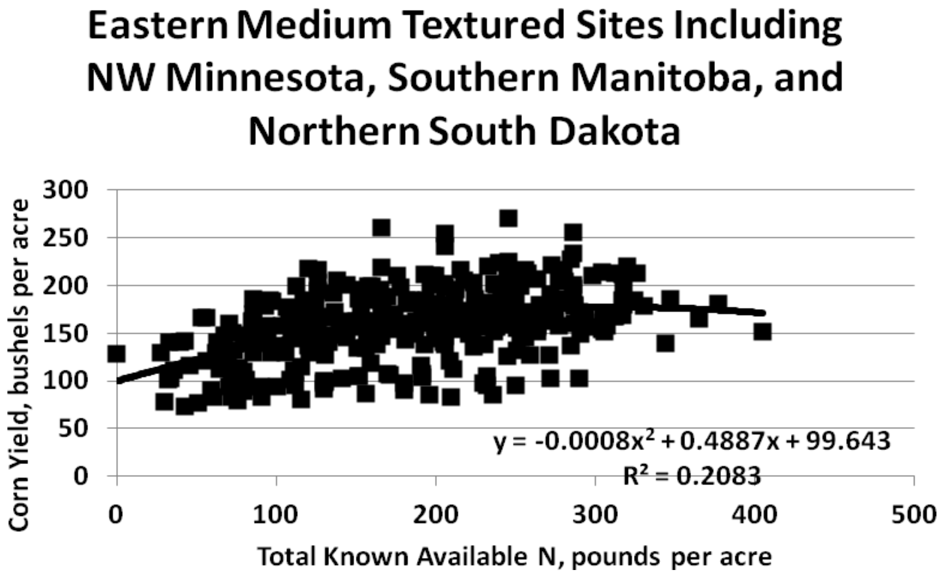

Figure 9. Response of corn to total known available N, all eastern medium texture conventional till sites.

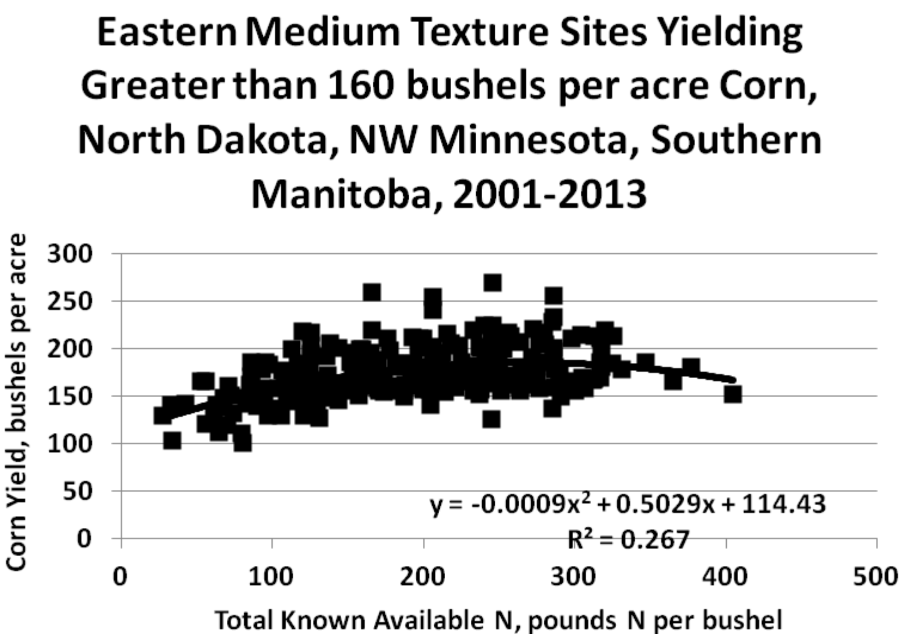

Figure 10. Response of corn to total known available N, all eastern medium texture conventional till sites with yield exceeding 160 bushels per acre.

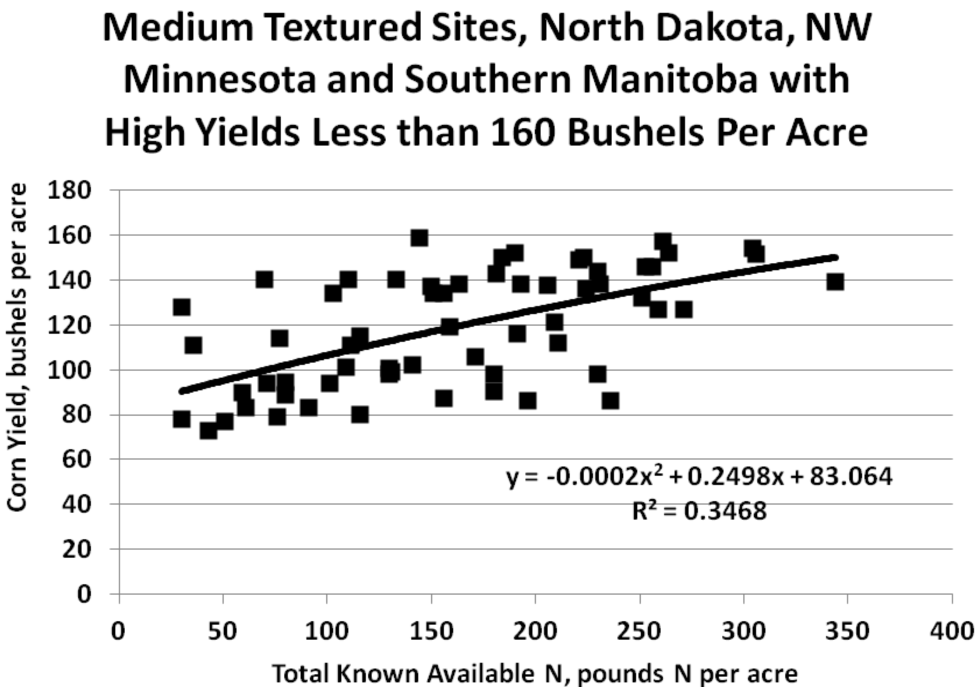

Figure 11. Response of corn to total known available N, all eastern medium texture conventional till sites with yields not exceeding 160 bushels per acre.

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