NITROGEN RATE REVISIONS FOR CORN IN NORTH DAKOTA – A PREVIEW OF COMING N FERTILIZATION STRATEGIES

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Introduction

Nitrogen rates in North Dakota have been based on a yield-goal or yield-potential formula for over forty years. The currently published formula (Franzen, 2010) is:

Recommended N rate = (Yield Potential, bushels per acre) X 1.2 less N credits from previous crops and soil test nitrate to 2 feet in depth.

A yield-based strategy was practical when N costs were relatively low and yields in North Dakota were at most 100 bushels per acre. However, 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 recommendation 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.

As of the writing of this proceedings paper, the harvest and analysis of the 2013 N rate studies are less than half completed. However, the objective of this paper is to provide a preview into the probable strategies of the upcoming North Dakota N recommendation revisions for corn that will be published in summer, 2014.

Materials and Methods

Eighty N rate trials in corn have been established in North Dakota since 2010 and this paper represents the harvest and analysis of seventy of those sites. Before the final publication of N rate revisions, incorporating N rate trials from colleagues working in northwest Minnesota and northeast South Dakota will supplement the overall data base. 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 was conducted within 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 should be analyzed separately from the 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.

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.

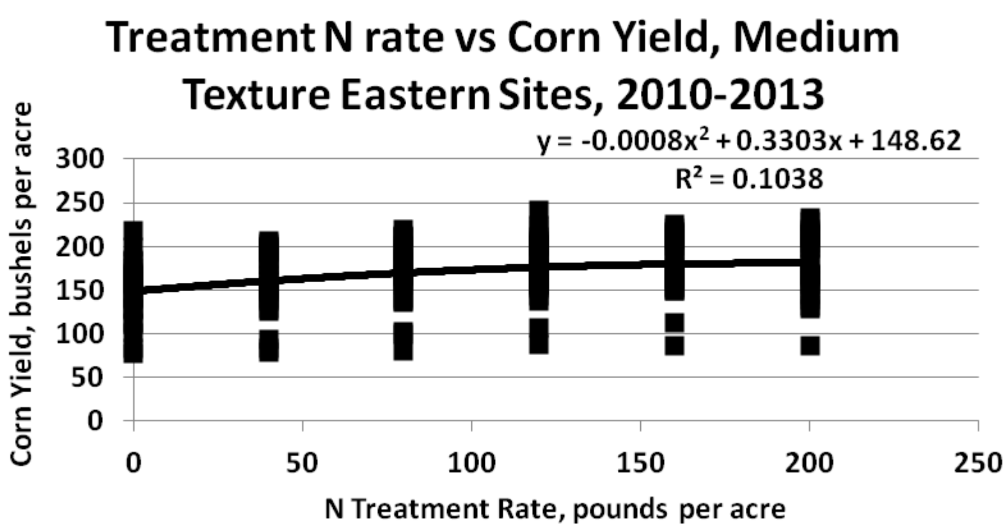

Figure 1a. Relationship between N treatment rate and corn yield for analyzed experiments with medium texture in eastern North Dakota, 2010 through partial 2013.

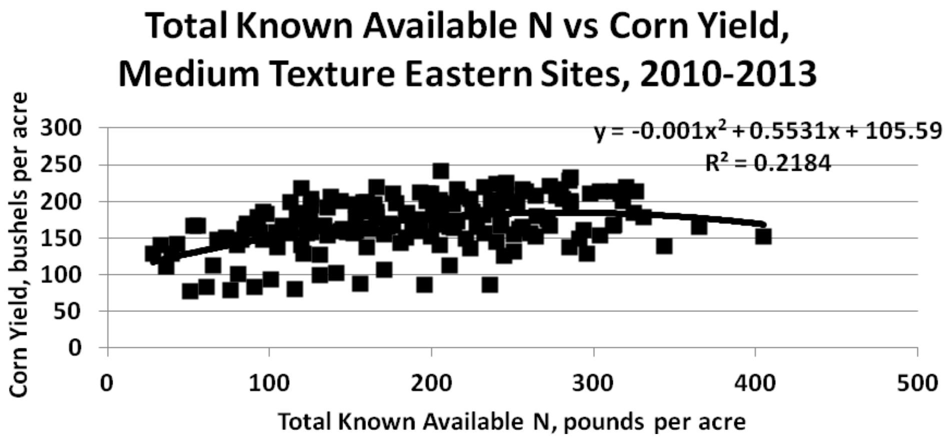

Figure 1b. Relationship between total known available N and corn yield for analyzed experiments with medium texture in eastern North Dakota, 2010 through partial 2013. Total known available N includes soil test nitrate to 2-feet in depth, N treatment rate and previous crop credit.

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 0.22 is not great, but it much exceeds the 0.10 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.

To illustrate that it is important to separate high clay soils from medium texture soils and long-term no-till sites from conventional tillage, the return to N for a selected currently relevant pair of conditions is represented in Figure 3. At 40 cent N per pound and a $4 per bushel corn price, the return to N for long-term no-till sites is less than medium-texture sites. Less additional N is required for profitable returns in long-term no-till than in either of the other two categories. High clay soils, with all N applied preplant, require much higher rates of N compared to medium texture and long-term no-till sites. Higher yields were achieved in medium texture soils in years with wet springs compared to yields in high clay soils. This suggests that high amounts of N are denitrified in high clay soils compared to medium texture soils in North Dakota. Figure 4 illustrates the N response in high clay soils in the particularly wet springs of 2010 and 2011, when it rained every few days and kept the high clay soils saturated with water for long periods, but the plots were not actually submerged. Maximum yield predicted by the regression equation describing the relationship in Figure 4 is over 1,500 lb N per acre, which is not a reasonable rate for any grower to consider. 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 will strongly urge growers to split apply N and apply a nitrification inhibitor to any preplant N application.

To direct a side-dress application of N, active-optical sensors will be recommended to estimate the rate of N. Another paper in this conference (Sharma et al., 2013) introduces the North Dakota development of algorithms using a GreenSeeker™ (Trimble, Ukiah, CA) and Holland Crop Circle Sensor™ (Holland Scientific, Lincoln, NE). Side-dressing about one-half of the entire N requirements will protect that half of the N from any early season soil wetness and associated denitrification. If the spring becomes wet and denitrification is significant, the sensors should be able to recommend a higher N rate than originally planned and achieve close to optimal yields.

Summary

The revised North Dakota N recommendations for corn will 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 will be based on return to N economic production functions. In high clay soils, split application of N will be 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 revised N recommendations will be published in summer, 2014.

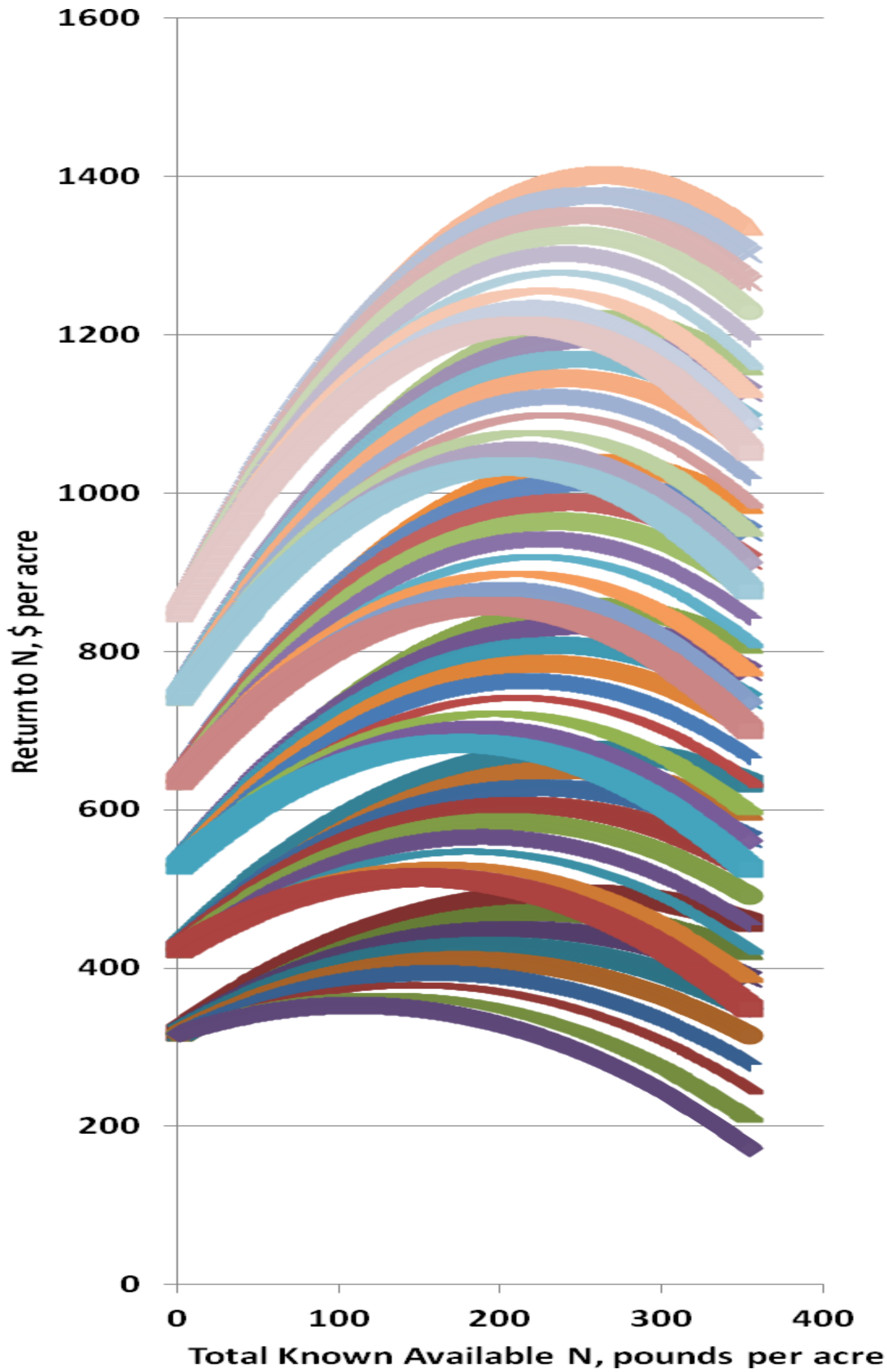

Figure 2. Return to N for N costs from 20 cents per pound of N to $1 per pound of N and corn prices between $3 per bushel and $8 per bushel. Bottom group of curves represents $3 corn price. Top group of curves represents $8 corn price. Within each group, the bottom curve represents $1 per pound of N, 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).

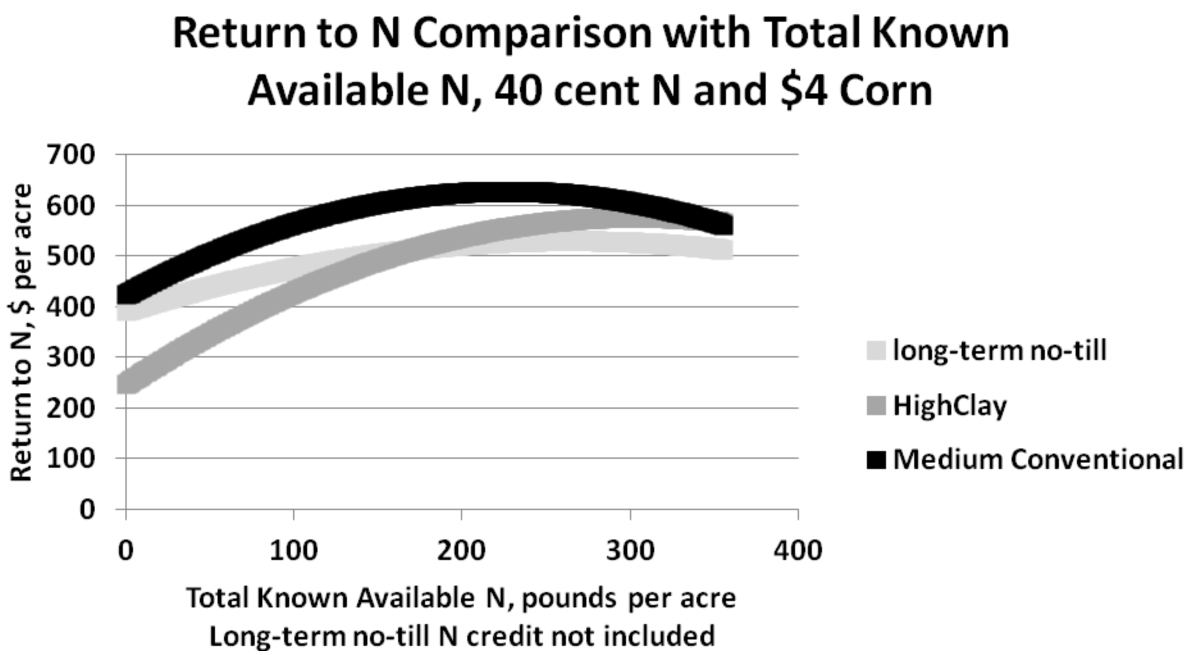

Figure 3. Return to N comparison to illustrate the differences in response curves between high clay sites, medium textured conventional sites and long-term no-till sites.

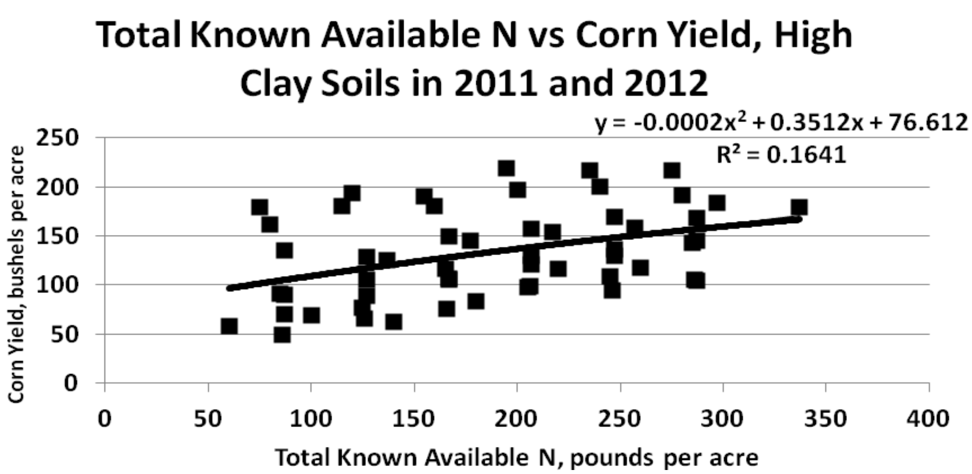

Figure 4. Response of corn to N in high clay soils in 2010-2011 when May and early June were wet after planting.

Acknowledgements

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