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FINAL REPORT
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PROJECT DESCRIPTION:	Improving Predictability and Adoption of Alfalfa N Credits for Corn
REPORT DUE DATE:	On or before **April 30, 2014**
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1.) GOALS AND OBJECTIVES OBTAINED

a) ***Analyze data for the literature analysis and write a technical article on the literature analysis.*** Data were analyzed and are summarized in a technical article that we wrote and published in *Agronomy Journal*.

b) ***Write an extension article on the literature analysis results for publication in farm magazines.*** Two articles were wrote and published in-print and online in *Progressive Forage Grower Magazine* and in *Dairy Star* magazine.

c) ***Develop and pre-test N credit questionnaire with a subset of alfalfa-corn farmers.*** An N credit questionnaire was developed and pre-tested with a subset of alfalfa-corn growers, agricultural professionals, and extension educators.

d) ***Analyze data for the grower survey and write a technical article on the grower survey.*** Data were analyzed and are summarized in a technical article that we wrote and submitted to *Agronomy Journal* for publication.

e) ***Present research results to farm advisors and growers at extension meetings.*** Research results were presented to farm advisors and growers at numerous extension meetings and field days.

f) ***Present research results to farm advisors, agency personnel, educators, and researchers at the North-Central Extension-Industry Soil Fertility Conference and at the American Society of Agronomy Annual Conference.*** Research results were presented at both of these conferences.

g) ***Conduct two specialized workshops on alfalfa nitrogen credits for farm advisors and consultants in regions with low alfalfa N credit adoption.*** We conducted three workshops in central Minnesota in March of 2013.

h) ***Obtain cropland data layer and soil type information and convert it into the necessary format for layering for geographic analysis of N management in alfalfa-corn rotations that is part of the Minnesota Agricultural Fertilizer Research and Education Council funded project titled "Improving Predictability and Adoption of Alfalfa N Credits for Corn: Part II."*** Data were collected from six states (Minnesota, North Dakota, South Dakota, Nebraska, Wisconsin, and Iowa) over seven years (2006-2012).

2.) ACTIVITIES PERFORMED AND OUTCOMES

a) To accomplish the goal/objective "*Analyze data for the literature analysis and write a technical article on the literature analysis.*" we conducted a literature-analysis on N fertilizer response in first-year corn after alfalfa to identify: i) which fields respond to N fertilizer; and ii) the economically optimum N rate (EONR) for responsive fields. This analysis was completed using data from 229 sites from the literature (1970-2011) and recent research we conducted on 31 farms in Minnesota (2009-2011).

The 260 valid sites of data for the final statistical analysis were from the following areas:

- Illinois = 6 sites
- Iowa = 35 sites
- Minnesota = 49 sites
- Missouri = 2 sites
- New York = 1 sites
- Ohio = 2 sites
- Ontario = 2 sites
- Pennsylvania = 6 sites
- Wisconsin = 157 sites

Step 1: Predict response to N fertilizer (yes or no)

Logistic multiple regression was used to develop models that could predict whether a field of first-year corn after alfalfa would respond to N fertilizer. For this analysis, the following predictor variables were considered using a stepwise approach:

- Surface soil [coarse = loamy sand (no experiments were reported on sands); medium = loam, silt loam, sandy loam, and fine sandy loam; fine = clay loam and silty clay loam (no experiments were reported on clay soils)].
- Surface soil organic matter (%).
- Presidedress soil nitrate test for first-year corn following alfalfa (ppm).
- Alfalfa stand age at termination (years, including the year of establishment).
- Alfalfa stand quality at termination (poor = less than or equal to 1.5 plants/square foot or less than or equal to 33% alfalfa in the stand; fair = 1.6-3.4 plants/square foot or 34-66% alfalfa in the stand; good = 3.5 or more plants/square foot or 67% or more alfalfa in the stand).

- Time of alfalfa termination (fall or spring).
- Tillage used for the transition from alfalfa to corn (tillage or no-tillage).
- Total or monthly precipitation and monthly total air degree days for October, November, December, March, April, and May during the transition from alfalfa to corn. Our first priority was to make predictions before corn planting, and for this we used weather data through March. If those results were unsatisfactory, we included weather data through May to allow predictions prior to sidedressing. Predictions were developed for both total or monthly precipitation and the most accurate prediction equation was selected.
- Two-way interactions of these variables.

Separate logistic regression analyses were conducted to predict responsiveness to N fertilizer (yes or no) based on soil texture, timing of alfalfa termination, and alfalfa stand age at termination. These four analysis categories were:

Fine-textured soils:

1. Across alfalfa termination timings and alfalfa stand ages

Medium-textured soils:

2. Alfalfa stand termination in the fall for 2-year-old stands
3. Alfalfa stand termination in the fall for 3-year or older-old stands
4. Alfalfa stand termination in the spring

Results from these four logistic regression analysis categories are presented below. Prediction equations could not be developed for medium-textured soils with fall termination of 1-year-old alfalfa stands due to variability among the limited sites of data for this category. We could not formulate a satisfactory logistic equation for coarse-textured soils, because corn responded to N fertilizer at 10 of the 11 sites. Thus, we must assume that the majority of coarse-textured sites will respond to fertilizer N for first-year corn after alfalfa.

The applicability of the logistic regression equations was evaluated for each state that had a responsive trial by applying the equations to 30 years of historic weather data (1983-2012) for counties that had the greatest number of alfalfa acres in the selected states (Figure 1).

Step 2: EONR prediction

For trials that had a significant response of corn grain yield to N fertilizer, appropriate regression equations (linear, linear-plateau, quadratic, or quadratic-plateau) were used to relate corn grain yield to N fertilizer rate. The economic optimum N rate (EONR) was then calculated from these equations for fertilizer cost ($/lb)/corn grain price ($/bu) ratios ranging from 0.08 to 0.20 in 0.01 increments. These cost/price ratios represent the range over the last 25 years according to the USDA-Economic Research Service. We also predicted the N rates for these cost/price ratios that provide a range in net return to N fertilizer within $1.00/acre of the maximum. Multiple linear regression with the stepwise selection procedure was then used to predict the EONRs and the potential predictors were the same as those used for the multiple logistic regression models.

Results for fine-textured soils:

Response to N:

The equation developed for 19 sites of first-year corn on fine-textured soils correctly predicted 89% of the non-responsive site-years and 90% of the responsive site-years. According to this equation, the odds of first-year corn responding to N fertilizer decrease with increasing alfalfa stand age and increase with air temperature in March.

The effect of stand age is clear when this model is applied to 30 years of weather data (Figure 1). This extrapolation of the model to historical weather indicates that response to N fertilizer in first-year corn would be most frequent in Iowa, Illinois, Missouri, Ohio, and Pennsylvania, and least frequent in Minnesota and Wisconsin. It is also apparent that the likelihood of a corn yield response to N fertilizer declines faster with alfalfa stand age in regions with colder March temperatures.

EONR prediction:

For the 9 of 19 sites in this category that had a response of corn grain yield to N fertilizer, the median EONR at the 0.10 cost/price ratio was 90 lb N/acre and the EONR could be predicted with high accuracy (Figure 2). The EONR at the 0.10 cost/price ratio decreased with an increase in the product of alfalfa stand age x November air temperature, and it increased with an increase in the product of October temperature x December precipitation.

When this prediction equation was applied to past 30 years of weather data from Minnesota, Iowa, and Missouri, the median EONR at the 0.10 cost/price ratio was less than 89 lb N/acre and it decreased by 21 to 75 lb N/acre as alfalfa stand age at termination increased (Figure 3). The range of EONR predicted for a given stand age and location indicates that a single 'book value' for the alfalfa N credit probably is inadequate for actual conditions in grower's fields.

Results for medium-textured soils with fall alfalfa termination:

Response to N:

There were 181 sites with medium-textured soils and fall alfalfa termination. Of these, 16, 79, and 86 sites were for 1-, 2-, and 3-or-more-year-old alfalfa stands, respectively. Corn grain yield responded to N fertilizer in 9 of 16 sites with 1-year-old alfalfa stands and in 21 of 79 sites with 2-year-old alfalfa stands, but in only 4 of 86 sites with alfalfa stands that were 3 or more years old at termination.

EONR prediction:

EONR prediction was not possible because only 4 sites had a response to N fertilizer.

Results for medium-textured soils with fall termination of 1-year-old alfalfa:

Response to N:

We were not able to formulate logistic regression equations that could predict responsive sites on medium-textured soils with 1-year-old alfalfa stands terminated in fall.

EONR prediction:

Although we could not predict with fields would respond to N fertilizer under these conditions, for the 9 of 16 sites in this category that showed a response of corn grain yield to N fertilizer, the median EONR at the 0.10 cost/price ratio was 127 lb N/acre and the EONR could be predicted by December and March air temperature and April precipitation (Figure 2).

Results for medium-textured soils with fall termination of 2-year-old alfalfa:

Response to N:

Two contrasting establishment methods were used for 2-year-old alfalfa stands terminated in fall on medium-textured soils. In 54 sites from long-term trials where alfalfa was seeded with oat but not harvested in the establishment year, corn yield responded to N fertilizer about 35% of the time. In contrast, corn responded only 8% of the time in 25 sites where alfalfa was direct-seeded and harvested during the establishment year. Therefore, establishment method was included a potential predictor. The logistic multiple regression equation correctly predicted 76% of the non-responsive sites and 81% of the responsive sites.

According to this equation, the odds of first-year corn responding to N fertilizer when alfalfa was seeded with oat increased with October air temperature, but there was no effect of weather on corn N response after alfalfa that was direct seeded. Cooler air temperatures may reduce mineralization of alfalfa residues, thereby reducing N losses prior to corn N uptake.

When this model was applied to the 30-year weather dataset, first-year corn responded to N fertilizer less than 5% of the time when the alfalfa was direct-seeded (Figure 1). When alfalfa was seeded with oat, response to N fertilizer in first-year corn was much more frequent and occurred about 15 to 20% of the time in Minnesota and Wisconsin, compared to about 65 to 95% of the time in Iowa, Illinois, Missouri, Ohio, and Pennsylvania.

EONR prediction:

Due to the low frequency of corn response to N on medium-textured soils with 2-year-old direct-seeded alfalfa stands (2 of 25 sites), the EONR for this category could not be predicted. The EONR at the 0.10 cost/price ratio for the two responsive sites was 50 and 149 lb N/acre. For 2-year-old alfalfa stands seeded with oat, the average EONR at a 0.10 cost/price ratio at the responsive site-years was 135 lb N/acre, but predictions of the optimum N rates had poor accuracy (less than or equal to 25%).

Results for medium-textured soils with fall termination of alfalfa older than 2 years:

Response to N:

Only 4 of 86 sites of corn responded to fertilizer N after fall termination of alfalfa stands that were 3 years or older on medium-textured soils. The logistic multiple regression equation developed for these situations correctly predicted 96% of the non-responsive sites but only two of the four responsive sites. According to this equation, the odds of first-year corn responding to N fertilizer increase with May precipitation.

When this predictive equation was applied to 30 years of historical weather, first-year corn responded to N fertilizer in three of seven states (Iowa, Missouri, and Pennsylvania), but in only 1 of 30 years in each of these three states (Figure 1).

EONR prediction:

Due to the low frequency of corn response to N on medium-textured soils with alfalfa stands that were at least 3 years old and terminated in the fall (4 of 86 sites), the EONR could not be predicted for this category. The EONR at the 0.10 cost/price ratio for the four responsive sites was 0, 81, 109, and 154 lb N/acre.

Results for medium-textured soils with spring alfalfa termination:

Response to N:

There were 48 sites with spring alfalfa termination on medium-textured soils. This logistic multiple regression equation was the most complex, having eight variables combined in four interactions, but it correctly predicted 98% of the non-responsive sites and 88% of the responsive sites.

According to this predictive equation, the odds of first-year corn responding to N fertilizer increase with the product of October air temperature x November precipitation and with an increase in the product of December air temperature x October precipitation. For this equation, the odds of first-year corn responding to N fertilizer decrease with an increase in the product of alfalfa stand age x December precipitation and with an increase in the product of March air temperature x March precipitation.

When this equation was applied to the 30 years of weather data, the number of years when first-year corn responded to N fertilizer decreased by 62 to 26% as alfalfa stand age increased from 2 to 5 years across all states except Missouri (Figure 1).

EONR prediction:

For the 8 of 48 sites in this category that showed a response of corn grain yield to N fertilizer, the EONR at a 0.10 cost/price ratio ranged from 43 to 157 lb N/acre and it could be predicted (Figure 2). The EONR at the 0.10 cost/price ratio increased with an increase in the product of alfalfa stand age x November air temperature, and it decreased with an increase in the product of October air temperature x November precipitation. When this predictive equation was applied to past 30 years of weather data from Minnesota, Iowa, and Missouri, the median EONR at the 0.10 cost/price ratio increased by 23 lb N/acre in Minnesota and by 53 lb N/acre in Iowa and Missouri as alfalfa stand age at termination increased from 3 to 5 years (Figure 3).

Results for coarse-textured soils:

Response to N:

Logistic regression equations could not predict sites with corn response to N fertilizer on coarse-textured soils, because only 1 of the 11 sites did not respond to fertilizer N.

EONR prediction:

For the 10 responsive sites in this category, the EONR at the 0.10 cost/price ratio ranged from 86 to 210 lb N/acre and it could be predicted (Figure 2). The EONR at the 0.10

cost/price ratio increased with increasing December air temperature when alfalfa was terminated in the spring, and it also increased with increasing total precipitation in October-December and March.

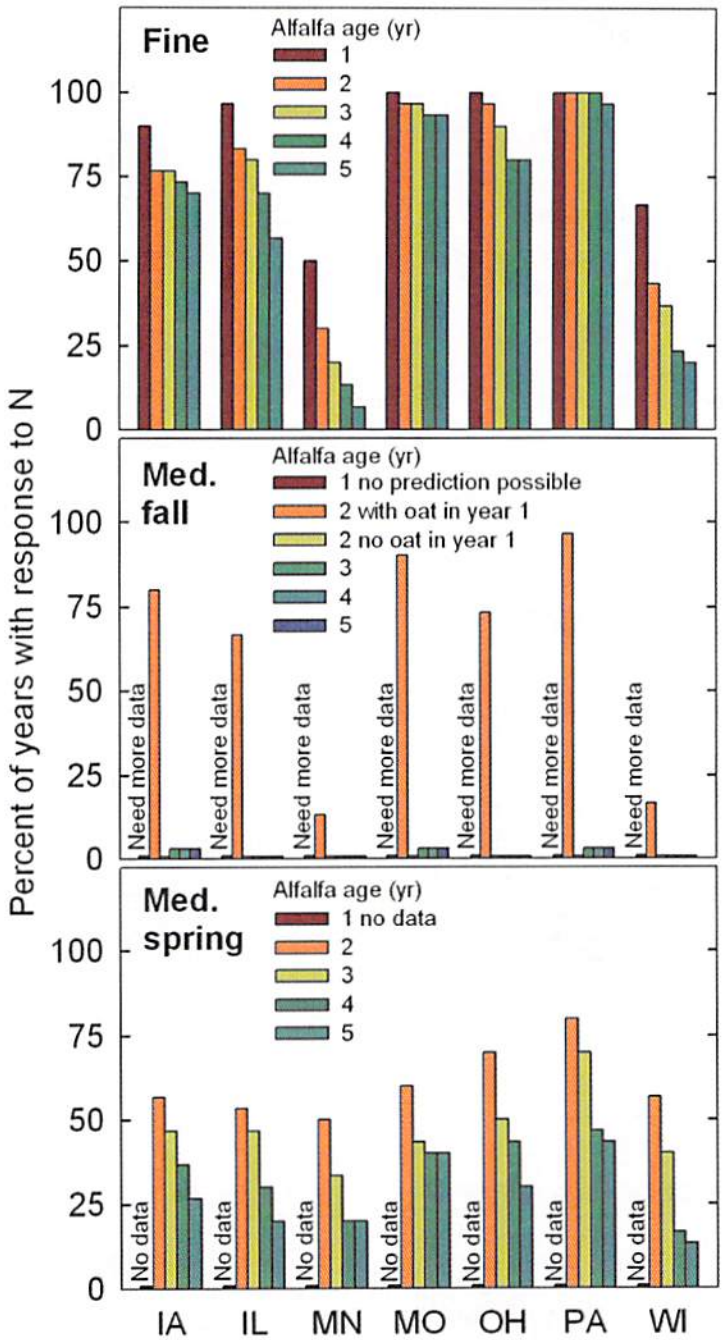

Figure 1. Predicted probability of grain yield response to N fertilizer for first-year corn after alfalfa based on 30 years (1983-2012) of weather data for one county in each of seven states, based on soil texture (Fine = fine-textured; Med. = medium-textured), alfalfa stand age (including establishment year), and alfalfa termination time (fall or spring).

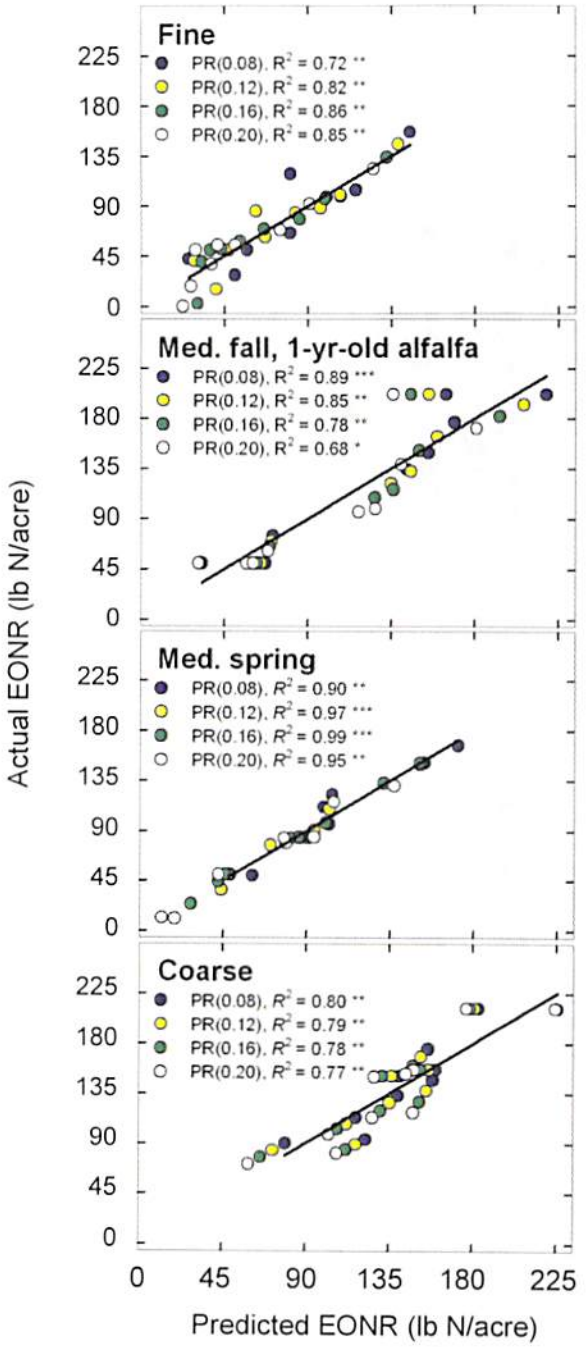

Figure 2. Actual versus predicted economically optimum N fertilizer rates (EONR) at the indicated N fertilizer cost/grain price ratios for first-year corn after alfalfa for fine-textured soils across alfalfa stand ages and termination times, medium-textured soils with 1-year-old alfalfa stands and fall termination, medium-textured soils with spring alfalfa termination across alfalfa stand ages, and coarse-textured soils across alfalfa stand ages and termination times.

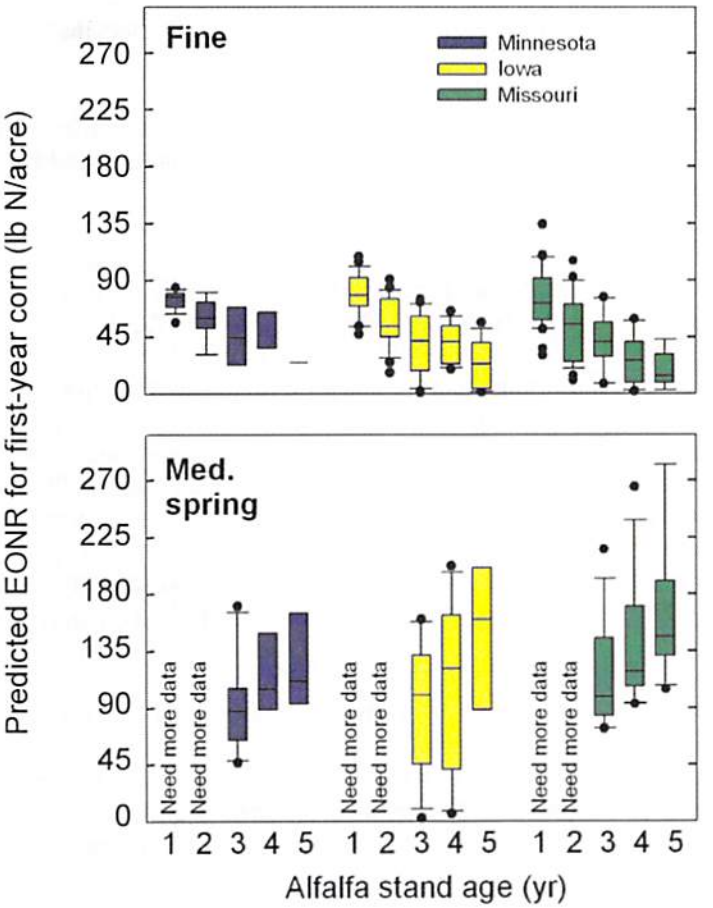

Figure 3. Predicted economically optimum N fertilizer rate (EONR) at the 0.10 fertilizer N cost/grain price ratio for first-year corn after alfalfa based on 30 years (1983-2012) of weather data for one county in each of three states, and shown by soil texture (Fine = fine-textured; Med. = medium-textured) and alfalfa stand age (including establishment year).

Next Steps:

These prediction equations appear robust and are based on the largest possible database of grain yield response to N fertilizer for first-year corn after alfalfa in North America. The prediction equations involve simple variables that could be used on site to: i) predict whether first-year corn after alfalfa is likely to respond to additional N; and ii) estimate the EONR within $1.00/acre. Research is needed to independently validate these prediction equations using new data from field trials of corn N response from a wide range of alfalfa stands, soil textures, and growing environments.

Technical article:

Results from this literature analysis are summarized in a technical article that we wrote and published in *Agronomy Journal*:

Yost, M.A., M.P. Russelle, and J.A. Coulter. 2014. Field-specific fertilizer nitrogen requirements for first-year corn following alfalfa. *Agronomy Journal* 106:645-658. doi:10.2134/agronj2013.0416

b) To accomplish the goal/objective "*Write an extension article on the literature analysis results for publication in farm magazines*," we wrote the following article titled "Yield and nitrogen benefits for corn when following alfalfa" and published it in *Progressive Forage Grower Magazine*. This article summarizes results from the comprehensive literature review for this project and it also integrates results from previous on-farm alfalfa-corn N management experiments that were funded by the Minnesota Agricultural Fertilizer Research and Education Council and the Minnesota Corn Research and Promotion Council. This article that was published in print on pages 32-33 of the November 2012 issue of *Progressive Forage Grower Magazine*, which has over 24,100 subscribers. In addition, this article was published online on this magazine's website on November 12, 2012. This article also was also published on pages 40-41 of the January issue of the magazine titled *Progressive Dairyman – Canada*, and it was posted on this magazine's website on December 21, 2012.

In addition, we wrote a second article summarizing the research results from this project. This article is titled "Nitrogen for corn following alfalfa: When and how much?" and is included below. This article was published in print and online in the February 23, 2013 issues of *Dairy Star* magazine. This magazine has over 14,200 in-print subscribers in Minnesota, eastern South Dakota, northern Iowa, and western Wisconsin, of which 11,400 are dairy/crop producers.

Yield and Nitrogen Benefits for Corn when Following Alfalfa

By, Jeff Coulter[1], Matt Yost[1], and Michael Russelle[2]

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Yield boost when corn follows alfalfa: Rotating alfalfa with corn can increase corn yield potential through improved soil physical properties that enhance water infiltration and root extension, a reduction in disease and pest pressure (i.e., corn rootworm), and an enhanced soil microbial community. For example, over 15 years on a silt loam soil in southwestern Wisconsin with fertilizer nitrogen (N) applied at rates high enough to maximize corn yield in all crop rotations, researchers from the University of Wisconsin found that yield was 19% (27 bushels per acre) higher for first-year corn after alfalfa than continuous corn, while second-year corn after alfalfa and corn after soybean yielded similarly and 10% (16 bushels per acre) higher than continuous corn. In comparison, over 26 years on a loam soil in northeastern Iowa with fertilizer N rates sufficient for maximum yield, researchers from Iowa State University found highest yields with first-year corn after alfalfa and corn following soybean, intermediate yields with second-year corn after alfalfa, and lowest yields with continuous corn and second- or third-year corn following soybean. Conversely, high water removal by alfalfa can reduce the yield of the following corn crop in dry years if there is insufficient recharge of water in the soil profile during the fall or spring prior to corn.

Substantial nitrogen credits from alfalfa to corn: Another benefit from alfalfa is the N that is supplied to the following corn crops. When compared to continuous corn, guidelines from universities in the Upper Midwest suggest that fertilizer N needs following the termination of a good stand of alfalfa (at least four plants per square foot) can generally be reduced by up to 100% for first-year corn and by up to 50% or more for second-year corn. These N credits from alfalfa to corn are largely the result of N-rich inputs to the soil organic matter pool. These inputs which include alfalfa leaves and stems lost during harvest, alfalfa stand losses over time, turnover of thin alfalfa roots, and exudation of substances from alfalfa roots, can rapidly mineralize after alfalfa stand termination and release N for at least two years.

Previous research in the northern U.S. found that the grain yield of first-year corn following alfalfa was not increased with fertilizer N in 91% of 140 fields. These fields had good alfalfa stands at the time of termination, were in alfalfa production for at least one full year prior to termination, were typically terminated in the fall and with tillage, and generally had deep soils with medium to fine texture. Fields with the most frequent N response tended to have fine-textured soils that were inadequately drained or course-textured soils, coupled with excess rainfall between the time of alfalfa termination and early-season corn growth.

Recent on-farm research confirms first-year nitrogen credits from alfalfa to corn: To determine whether alfalfa N credit guidelines for first-year corn still apply with contemporary, high-yielding corn crops, we conducted research on 32 farms across Minnesota and western Wisconsin from 2009 to 2011. The first study evaluated the response of first-year corn yield to fertilizer N applied near planting on five farms in 2009 and on five farms in 2010 that had good alfalfa stands at the time of termination and medium- to fine-textured soils. First-year corn yield averaged over 195 bushels grain per acre on seven of the ten farms and over 24 tons silage per acre on seven of the nine farms where it was measured, yet first-year corn grain and silage yields were not increased when fertilizer N rates up to 160 pounds N per acre were applied. On seven of these ten farms, residual soil nitrate-N was measured to a depth of four feet in the fall after corn harvest. Results showed minimal increase in residual soil nitrate-N when 40 pounds N per acre was applied near planting, likely due to luxury consumption by the corn crop. However, residual soil nitrate-N increased rapidly when more than 40 pounds N per acre was applied. A high amount of residual soil nitrate-N remaining after harvest is a concern because the N is susceptible to loss through leaching and denitrification.

The second study that we conducted evaluated the response of first-year corn to fertilizer N, and whether this was affected by the amount of alfalfa regrowth in the fall and the timing of tillage (disk-chiseling) for alfalfa termination. This research was conducted on six farms in southern and central Minnesota in 2010 with medium- to fine-textured soils and good alfalfa stands at the time of termination. Surprisingly, the presence of fall alfalfa regrowth did not affect first-year corn grain or silage yields or their response to fertilizer N applied near planting (0 to 160 pounds N per acre), even though this alfalfa regrowth averaged 11 inches with 33 pounds N per acre across the six farms. Similarly, there was no effect of tillage timing on first-year corn grain and silage yields. These results indicate that growers should harvest alfalfa regrowth in the last year on medium- to fine-textured soils with good alfalfa stand densities, and that growers have some flexibility in tillage timing when terminating alfalfa. In this study, first-year corn grain yield responded to fertilizer N at only one of six farms, even with average yields of 180 to 231 bushels per acre. On the one responsive farm where 70 to 81 pounds N per acre was needed to economically optimize grain yield, there was fine-textured soil, abundant early-season rainfall, and inadequate drainage, which likely slowed N mineralization due to low oxygen levels in the soil. However, across all farms fertilizer N was needed (42 to 64 pounds N per acre) to

economically optimize corn silage yield, even though silage yield was increased by just 3% with N.

No-till can work well for first-year corn after alfalfa: In 2010 and 2011, we conducted a third study on seven no-till farms across southern Minnesota and western Wisconsin to evaluate the response of first-year, no-tillage corn grain and silage yields to fertilizer N applied near planting (0 to 160 pounds N per acre). These farms had medium- to fine-textured soils and good alfalfa stands at the time of alfalfa stand termination, and the cooperating farms applied a small amount of starter fertilizer N at planting. Grain yield on these seven farms averaged 199 to 220 bushels per acre and silage yield averaged 21.1 to 30.3 tons per acre on the four farms where it was measured, yet grain and silage yields were not increased with fertilizer N. On one of these farms with clay loam soil in southwestern Minnesota we also compared no-till with fall disk-chiseling, but found no differences in grain yield or its response to fertilizer N.

When nitrogen is needed for first-year corn after alfalfa, a small sidedress rate can suffice: In 2011, a fourth study was conducted on nine farms in southern and central Minnesota with medium- to fine-textured soils and good alfalfa stands at the time of termination with tillage. In this study, we evaluated the response of corn grain yield to fertilizer N applied near planting or as a sidedress application when corn was at the six leaf collar stage. Grain yield was increased with fertilizer N on just three of these nine farms. When fertilizer N was applied near planting, the economically optimum N rate was 40 pounds N per acre on one farm and 80 pounds N per acre on two farms, but equivalent yields were obtained on these farms with just a sidedress application of 40 pounds N per acre. Response to fertilizer N on these three farms in 2011 was likely related to above-average early-season precipitation and low oxygen levels in the soil that limited mineralization of N.

Take home points for first-year corn after alfalfa:

- Increased yield potential compared to other crop rotations.
- If possible, harvest alfalfa regrowth in the fall before stand termination, especially if the stand density is good.
- No-till can work well for first-year corn, even on fine-textured soils.
- On medium- to fine-textured soils with good alfalfa stands at termination, first-year corn grain yield was increased with fertilizer N on only 4 of 32 farms (13% of time).
- It may be more common for silage corn to respond to a small amount of N than grain corn.
- Soil nitrate-N after harvest can increase greatly if rates above 40 pounds N per acre are applied to first-year corn and if N is not needed to optimize yield.
- The chance of first-year corn responding to N can increase if there is significant rainfall between alfalfa termination and early-season corn growth on fine-textured soils that are inadequately drained or on sandy soils.
- If one anticipates that fertilizer N is needed for first-year corn after alfalfa, consider a small amount of N in a starter fertilizer, or consider a small sidedress application (around

40 pounds N per acre) depending on early-season growing conditions rather than a high N rate applied near planting.

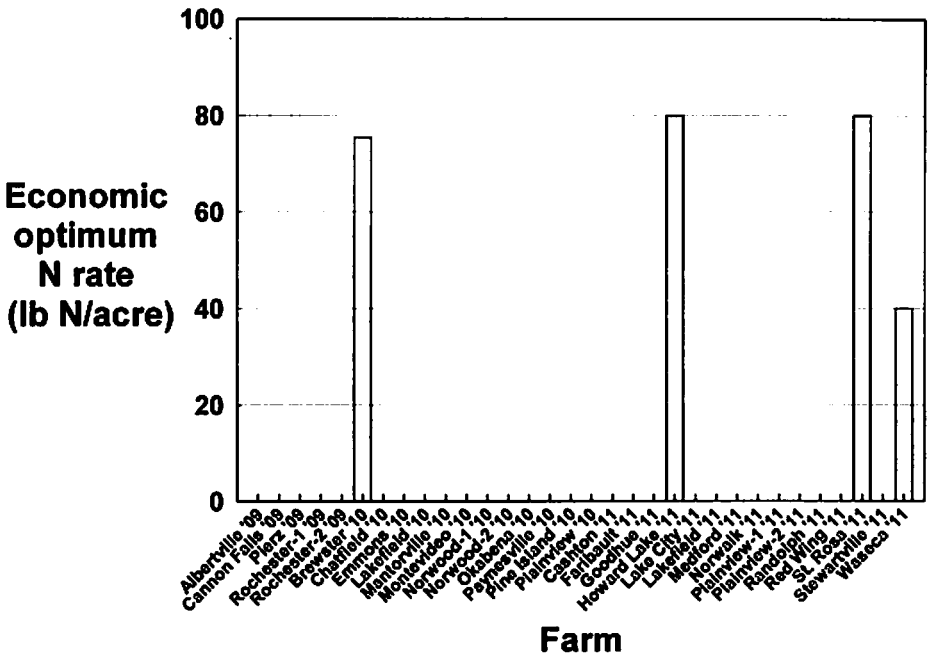

Figure 1. Economically optimum fertilizer nitrogen (N) rate for N applied near planting on 32 farms in Minnesota and western Wisconsin, based on a fertilizer N cost/grain price ratio of 0.07. Fertilizer N increased corn grain yield on just 4 of 32 farms.

Acknowledgements: The authors greatly appreciate the financial support for this research, which was provided by the Minnesota Agricultural Fertilizer Research and Education Council, the Minnesota Corn Growers Association, the USDA-Sustainable Agriculture Research and Education Program, the Minnesota Agricultural Water Resource Center, the Hueg-Harrison Fellowship, and the USDA-Agricultural Research Service.

Nitrogen for Corn Following Alfalfa: When and How Much?

Matt Yost[1], Jeff Coulter[1], and Michael Russelle[2]

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Growers usually enjoy a yield boost when corn follows alfalfa. The major reasons: reduced pest and disease pressure, better soil structure that enhances root growth and water infiltration, and an altered soil microbial community. In addition, when corn follows alfalfa the economically optimum nitrogen (N) fertilizer rate is much less than when corn follows other crops. When compared to continuous corn, current University of Minnesota guidelines suggest that growers reduce N fertilizer applications for first-year corn after alfalfa by 150 pounds N/acre when there is a good stand of alfalfa (at least 4 alfalfa plants/square foot) at the time of termination. The

guidelines also suggest that the N fertilizer rate for second-year corn after alfalfa be reduced by 75 pounds N/acre when a good alfalfa stand is terminated. These reductions in N fertilizer for corn following alfalfa are known as N credits, and the N passed onto corn is largely due to additions of N-rich inputs from alfalfa to the soil. These inputs include things such as alfalfa leaves and stems lost during harvest, alfalfa stand losses over time, turnover of thin alfalfa roots, and substances that exude out of alfalfa roots.

Recent research on 31 farms in Minnesota and western Wisconsin from 2009 to 2011 has confirmed N credits for first-year corn following alfalfa and investigated how these credits are affected by potassium fertility during the last alfalfa year, amount of alfalfa regrowth at termination, termination time (fall vs. spring), no-tillage, and fall manure application. Surprisingly, none of these factors affected the economically optimum N rate for first-year corn after alfalfa and N fertilizer increased grain yield on only 3 of the 31 farms. This research supports university recommendations and indicates that 90% of the time, N from fertilizer or manure is not needed for first-year corn after alfalfa. On the 3 of 31 farms where N was needed, grain yield was optimized with 80 lb N/acre when applied near planting or with just 40 lb N/acre when sidedressed. The three responsive farms had fine-textured soils and excessive early-season precipitation.

Prior to the 31 recent on-farm trials in Minnesota and western Wisconsin, results from 200 other N rate trials in first-year corn after alfalfa were gleaned from the literature. Together, these 231 trials were analyzed to determine the underlying factors affecting N response in first-year corn. Results indicate that the response to N is strongly influenced by soil texture. On coarse-textured soils (loamy sands), N fertilizer was needed to optimize grain yield of first-year corn 96% of the time. The high frequency of response to N on coarse-textured soils is likely due to high potential for leaching of mineralized N. On fine-textured soils (clay loams, silty clay loams, and sandy clay loams), N fertilizer was needed 50% of the time. Response to N on fine-textured soils typically occurred in years when there was excessive early-season soil moisture, which likely slowed mineralization of N by soil microorganisms due poor soil aeration. On medium-textured soils (loams, silt loams, sandy loams, and fine sandy loams), the response to N was dependent on the time of tillage for alfalfa termination. On medium-textured soils, first-year corn responded to N fertilizer only 4% of the time when alfalfa was terminated in the fall, compared to 20% of the time when alfalfa was terminated in the spring. More frequent response to N when alfalfa was terminated in the spring on medium-textured soils was likely due to less time for mineralization of N before rapid N uptake by corn.

To better understand and predict N credits from a good stand of alfalfa to second-year corn, 11 on-farm trials were conducted across southern and central Minnesota in 2011 and 2012. We were surprised to find that N fertilizer did not increase the grain yield of second-year corn on 4 of 11 farms. The economically optimum N rate varied among the seven responsive farms, but was often at least half as large as that for continuous corn. As in first-year corn, sidedress applications of N allowed growers to reduce fertilizer rates without sacrificing yield. These results indicate that N credits for second-year corn after alfalfa are reliable in most cases and are sometimes much higher than expected.

When possible, growers should consider planting two years of corn after alfalfa to take full advantage of alfalfa N credits. Current research is focused on developing predictive models to determine the conditions that cause first- and second-year corn after alfalfa to respond to N fertilizer, and to better predict the economic optimum N rates in fields where a response to N is expected.

The authors greatly appreciate the financial support for this research, which was provided by the Minnesota Corn Growers Association, the Minnesota Agricultural Fertilizer Research and Education Council, the Minnesota Agricultural Water Resource Center, the USDA-Sustainable Agriculture Research and Education Program, the Hueg-Harrison Fellowship, and the USDA-Agricultural Research Service.

c) To accomplish the goal/objective "*Develop and pre-test N credit questionnaire with a subset of alfalfa-corn farmers,*" we worked closely with the USDA-National Agricultural Statistics Service to develop an eight-page survey questionnaire to assess the adoption rate of recommended N credits for corn grown after alfalfa, and to learn reasons for not fully accepting recommended N credits. This questionnaire was pre-tested with a subset of alfalfa-corn growers, agricultural professionals, and extension educators. We also developed an advance notice letter, a cover letter for the first questionnaire, a thank-you/reminder post card, and a cover letter for the follow-up questionnaire, along with a special version of this questionnaire that was used for the phone follow-up survey.

d) The goal/objective "*Analyze data for the grower survey and write a technical article on the grower survey*" has been completed. The background, methods, results, and conclusions of this work are summarized below.

Background:

This survey was conducted to determine:

i) how growers manage the combination of all N sources (alfalfa, manure, and fertilizer) during the rotation from alfalfa to corn;

ii) how alfalfa stand condition, the basis of alfalfa N credit guidelines from most land-grant universities in the midwestern United States, affects N credit adoption;

iii) which farm, grower, and agronomic factors relate to alfalfa and manure N credit adoption for first- and second-year corn after alfalfa;

iv) how adoption of extension N rate guidelines relate for corn grown in other rotations; and

v) which sources of information about N management for corn after alfalfa are preferred by growers.

This information is needed to target research and education of best management practices for alfalfa-corn rotations.

Methods:

To answer these questions, we worked with the USDA-National Agricultural Statistics Service in 2012 to mail a detailed eight-page N management questionnaire to all 2,196 Minnesota growers that had at least 100 acres of alfalfa and 50 acres of corn in 2011. These growers were located in 83 of the 87 counties in Minnesota. The questionnaire had four sections. The first section asked growers about acres farmed, the county where most of their alfalfa was grown, and crops other than corn that they plant as the first- and second-year crops after alfalfa. The second section of the questionnaire asked growers to select one field typical of their operation that was first-year corn after alfalfa in 2009 or 2010. The questions in this section focused on the alfalfa termination, manure application, and first-year corn

management for the typical field. The third section of the questionnaire was similar to the second section, but was for second-year corn after alfalfa in the same field in the following year. The fourth section included questions about N application from manure and fertilizer for continuous corn (at least the third consecutive crop of corn) and corn following soybean. The fourth section of the questionnaire asked questions about decision making for manure and N fertilizer N management, the sources of information on N fertilizer and manure management that were considered most reliable, and farm and grower demographics.

The survey process consisted of an advance notice letter, mailing of the questionnaire, a thank you/reminder post card, a second mailing of the questionnaire to non-respondents, and a phone follow-up questionnaire for growers that did not respond to the mailed questionnaires. There were 819 questionnaires completed, with 27% from the first mailing, 18% from the second mailing, and 55% over the phone.

When respondents did not supply available manure N rates, they were estimated using University of Minnesota Extension guidelines based on the reported manure application type, amount, and incorporation timing. Total N rates for corn were the sum of available manure N and fertilizer N. The total N rate for second-year corn after alfalfa also included available N carryover from manure applied to first-year corn after alfalfa.

Alfalfa stand condition (excellent/good, fair, or poor) reported by growers was used to determine corresponding alfalfa N credits to first- and second-year corn after alfalfa according to current University of Minnesota Extension guidelines. Alfalfa N credit guidelines are 150, 100, and 40 lb N/acre for first-year corn after alfalfa, and 75, 50, and 0 lb N/acre following good (4 or more plants plants/square foot), fair (2-3 plants/square foot), and poor (1 or fewer plants per square foot) alfalfa stands, respectively. For each response, alfalfa N credits were added to total N rates applied for first- and second-year corn after alfalfa, while a soybean N credit of 30 lb N/acre was added to the total N rate for corn following soybean. Total N rates greater than 350 lb N/acre for first-year corn after alfalfa, continuous corn, and corn following soybean, and greater than 425 lb N/acre for second-year corn after alfalfa were considered outliers and excluded from the analysis. Similarly, total N rates below 80 lb N/acre for continuous corn and below 45 lb N/acre for corn following soybean were considered outliers and excluded. A higher exclusion limit was used for second-year corn after alfalfa to account for potential carryover of manure N from manure applied for first-year corn after alfalfa. After excluding incomplete, extreme, and invalid surveys, the total number of usable surveys was 486.

Total N rates for corn were subtracted from the highest N rate (160 lb N/acre) for net return to N within $1.00/acre of the maximum during 2006 to 2012, according to the University of Minnesota Extension guideline for continuous corn on highly productive soils, to determine corn N rate guideline adoption rates for all four rotations. Total N rates for first- and second-year corn after alfalfa without manure application that were less than or equal to 10% above the extension guideline were categorized as 'adoption' and rates that were more than 10% above the guideline were considered 'nonadoption.' Similarly, total N rates less than or equal to 20% above the extension guideline were categorized as 'adoption' for first- and second-year corn after alfalfa with manure application. The higher upper limit on the total N rate for classification as 'adoption' with manure was used to account for potential error in available manure N rate estimates. The second-year corn after alfalfa with manure category included fields with manure application to first- and/or second-year corn after alfalfa.

Adoption (yes or no) of extension N rate guidelines was evaluated using logistic regression analysis for first- and second-year corn after alfalfa, both with and without manure. The predictor variables considered for first-year corn after alfalfa were farm, grower, alfalfa, first-year corn characteristics, and the 12 most important factors reported by respondents as used to determine N fertilizer rates in first-year corn after alfalfa. Manure incorporation timing was included when manure was applied. In addition to all of the predictor variables used for first-year corn after alfalfa, variables used for second-year corn after alfalfa included farm, second-year corn characteristics, and the 12 most important factors reported by respondents as used to determine N fertilizer rates in second-year corn after alfalfa.

Predictor variables were classified into categories based on distributions of data. For subsets of growers who reported total N rates for corn after alfalfa and corn grown in one or more of the other rotations, logistic regression analysis was used to relate N rate guideline adoption among rotations.

Results:

Farm characteristics and terminated alfalfa:

The majority of the 421 growers with fist-year corn after alfalfa that provided a usable questionnaire were located in southeastern and central Minnesota (Figure 4). Many (60%) growers farmed 250 to 740 acres of cropland. Their major farm enterprises were dairy (51%) and crops (42%). Most growers (84%) received the majority of their total income in 2011 from their farm enterprise.

Nearly one-half (41%) of the 421 growers seeded their alfalfa with grass. More than half (68%) terminated alfalfa after 4 or 5 years, 29% terminated alfalfa when it was 6 years or older, and the remaining growers terminated at or before 3 years. Alfalfa termination was rarely planned and the most common reason for terminating alfalfa was the need for a place to apply manure. The second most common reason for alfalfa termination was thinning alfalfa stands; one-third (36%) selected this as their top reason. Responses were evenly distributed among the remaining reasons for terminating alfalfa (weedy alfalfa stands, winterkill, other). Alfalfa was terminated with tillage by 92% of growers and two-third (66%) of the growers terminated alfalfa with herbicide or tillage in the fall, whereas the remainder terminated alfalfa in the spring.

Manure was applied during the rotation from alfalfa to corn on two-third (64%) of the fields. One-half (48%) of the fields received manure in the fall only, but an additional one-third (33%) applied manure in both the fall and spring. Manure incorporation methods were almost equally split between: i) immediate [injection or incorporation within 12 hours (27%)]; ii) delayed [incorporation within 4 days (37%)]; and iii) none [incorporation after 4 days or no incorporation (36%)].

First-year corn after alfalfa:

The first-year corn after alfalfa fields selected by growers as typical of their operation were most often 50 acres or larger (65% of fields), not irrigated (94%), not tile drained (87%), on medium- (43%) or fine-textured soils (43%), and harvested for grain (68%). The top three factors reportedly used by growers to determine N fertilizer rates for first-year corn after alfalfa were corn yield goal (54% used), manure N (34%), and alfalfa yield in the last production year (27%) (Figure 6). Few growers (14%) used N fertilizer cost and corn price. These results indicate that many growers may use older extension N rate guidelines for

continuous corn that are based on yield goal as their base for N rates in first-year corn after alfalfa instead of current extension guidelines.

About one-third (37%) of respondents reported that they planted first-year corn following a good alfalfa stand, 45% followed fair stands, and 18% followed poor stands. The assumed economically optimum N rate for continuous corn on these fields was 160 lb N/acre, thus extension guidelines for first-year corn after alfalfa would suggest 10 lb N/acre after good alfalfa stands, 60 lb N/acre after fair stands, and 120 lb N/acre after poor stands. Based on these guidelines, 41% of the one-third of growers who applied only N fertilizer for first-year corn after alfalfa adopted the extension guidelines (applied no more than 10% above the guideline) (Figure 5). In comparison, 29% of the two-third of growers who applied manure to first-year corn after alfalfa adopted the extension guidelines (applied no more than 20% above the guideline).

Multiple logistic regression analysis was used to investigate which of the farm, grower, and field characteristics relate to adoption of extension N rate guidelines for first-year corn after alfalfa. When no manure was applied to first-year corn after alfalfa, the odds of growers applying fertilizer N rates above extension guidelines: i) increased when fair and good alfalfa stands were terminated relative to poor stands; ii) increased for fine- relative to medium-textured soils; iii) decreased for coarse- relative to medium-textured soils; and iv) increased when growers used yield goal as a factor for determining N fertilizer rates.

When manure was applied to first-year corn after alfalfa, some of the variables associated with adoption of extension N rate guidelines were the same variables associated with adoption when no manure was applied. Both improved alfalfa stand condition and first-year corn yield goal usage again increased odds of over-application of N when manure was applied, but the magnitude of the odds was much higher for first-year corn following both fair and good alfalfa stands with manure than without manure. The odds of over-application of N also increased when corn was frequently grown as the first crop after alfalfa relative to the infrequent use of corn, and when manure incorporation was immediate or delayed relative to no incorporation. Thus, when manure N credits were higher due to incorporation, growers were more likely to over-apply N relative to the extension guidelines. The odds of over-application decreased when growers used six or more other information sources to determine the N fertilizer N rate relative to fewer sources of information.

Second-year corn after alfalfa:

A total of 273 respondents (65%) grew a second consecutive crop of corn after alfalfa. Of the 217 growers who applied manure to either first- or second-year corn after alfalfa, 78% applied manure to both, whereas 13 and 9% applied manure to only first- or second-year corn after alfalfa. Manure application timing and incorporation method for second-year corn after alfalfa were similar to that for first-year corn after alfalfa, with 53% of the applications occurring in the fall and nearly equal representation of immediate, delayed, or no incorporation. The two most frequent factors used by growers to determine N fertilizer rates for second-year corn after alfalfa were the same as the top two used for first-year corn after alfalfa (Figure 6). Use of alfalfa yield during the last production year declined, while use of soil organic matter percentage, N fertilizer cost, corn price, and corn yield goal all increased for determination of N fertilizer rates in second-year corn after alfalfa relative to first-year corn.

Assuming 160 lb N/acre as the optimum rate for continuous corn in these fields, extension guidelines for second-year corn after alfalfa suggest 85 lb N/acre after good alfalfa stands, 110 lb N/acre after fair alfalfa stands, and 160 lb N/acre after poor alfalfa stands. Based on these guidelines, 34% of the growers that did not apply manure to first- or second-year corn after alfalfa adopted N fertilizer rate guidelines for second-year corn after alfalfa (Figure 5). One-fourth (25%) of the large proportion of growers that applied manure to first- and/or second-year corn after alfalfa met extension N rate guidelines for second-year corn after alfalfa.

The statistical analyses for second-year corn after alfalfa with and without manure both showed that alfalfa stand condition affected adoption of extension N rate guidelines. As with first-year corn after alfalfa, the odds of over-application of N increased when second-year corn after alfalfa followed improved alfalfa stands with larger N credits. When manure was applied, use of second-year corn yield goal when determining N rate increased the odds of over-application of N.

N management among crop rotations:

Of the 507 growers who provided N rates for both first-year corn after alfalfa and continuous corn or corn following soybean, 44% had either continuous corn or corn following soybean in addition to first-year corn after alfalfa, while one-fourth had both continuous corn and corn following soybean in addition to first-year corn after alfalfa. Subsets of these growers with reported N rates for corn in more than one rotation were analyzed to determine whether adoption of extension N rate guidelines for continuous corn and corn following soybean was related to adoption for first- and second-year corn after alfalfa. When manure was applied in both rotations, the odds of over-application of N for first-year corn after alfalfa increased when over-application of N occurred in continuous corn.

There were relationships between extension N rate guideline adoption for continuous corn and second-year corn after alfalfa, both with and without manure application. When growers over-applied N for continuous corn, they were more likely to over-apply in second-year corn after alfalfa. Adoption of N rate guidelines for corn following soybean was not related to adoption for first- or second-year corn after alfalfa with or without manure application, indicating a poor relationship between adoption of alfalfa and soybean N credits. The odds of over-application of N for second-year corn after alfalfa increased when over-application occurred in first-year corn after alfalfa; both with and without manure.

Sources of information for N management:

Reasons for limited adoption of extension N rate guidelines may vary. One-half of growers rated extension N rate guidelines as usually to always reliable sources for N management in first- and second-year corn after alfalfa (Figure 7). Other sources, including past experience, soil testing labs, fertilizer dealers, and independent crop consultants, were relied on more heavily than extension.

Nearly one-third of the growers indicated that they had hosted research trials on corn N management in the past and these trials on their own or neighboring farms were usually to always reliable sources of information nearly one-half of the time. Employees and family members also were rated as reliable about one-half of the time. The farm press was ranked as the least reliable source of N management information. Almost all (97%) of the growers themselves were involved in the decision about how much N to apply to first- and second-

year corn after alfalfa, 69% consulted fertilizer dealers, and 47% consulted with independent crop consultants when making decisions about N management for first- and second-year corn after alfalfa.

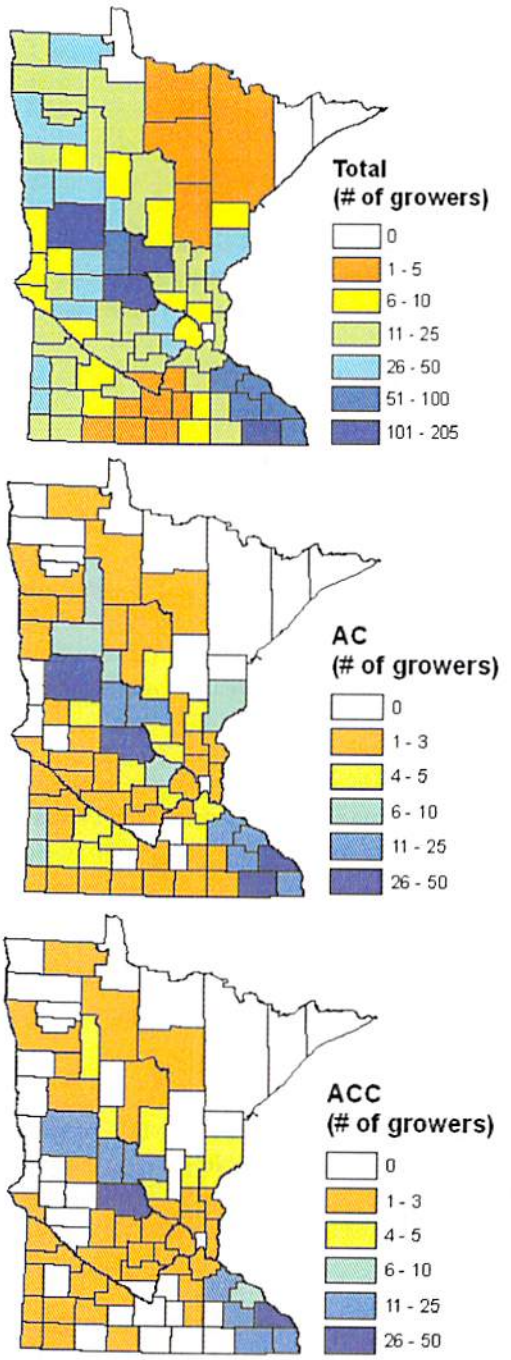

Figure 4. Distribution of the 2,196 growers with at least 100 acres of alfalfa and 50 acres of corn in 2011 who were surveyed in 2012 (top), distribution of the 421 valid responses for first-year corn after alfalfa (AC) (middle), and distribution of the 273 of 421 valid responses for second-year corn after alfalfa (ACC) (bottom).

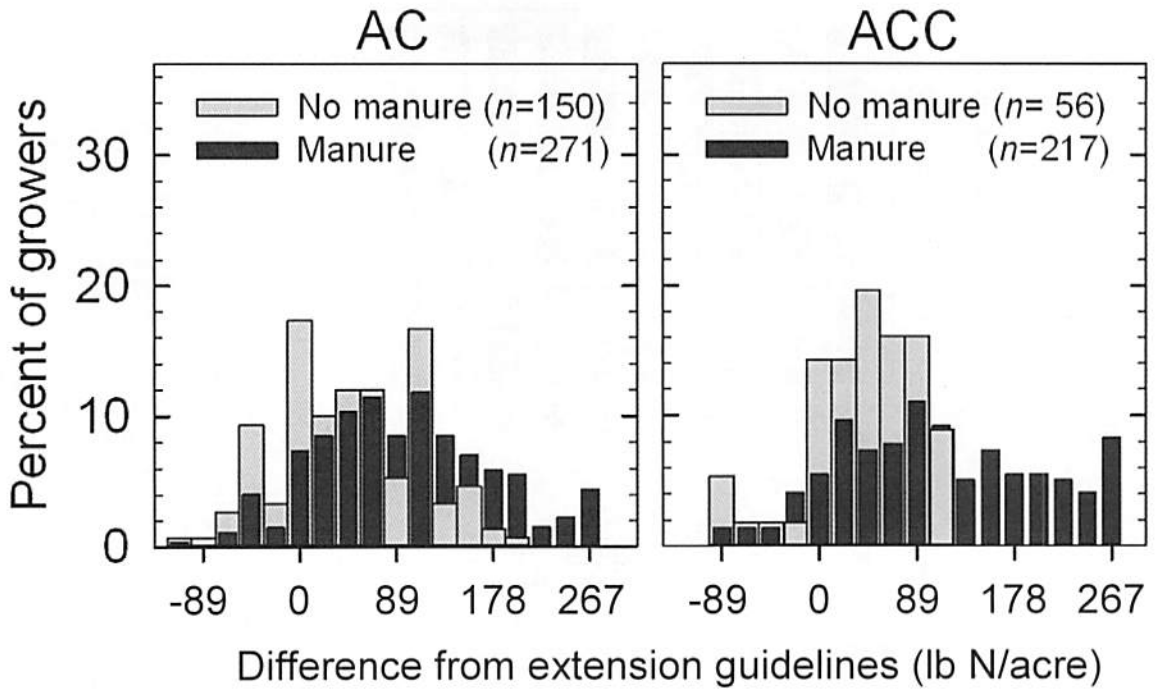

Figure 5. Difference between total N rate (alfalfa N credits + manure N + fertilizer N) for first-year corn after alfalfa (AC; left) or second-year corn after alfalfa (ACC; right) and an assumed continuous corn extension guideline rate of 160 lb N/acre.

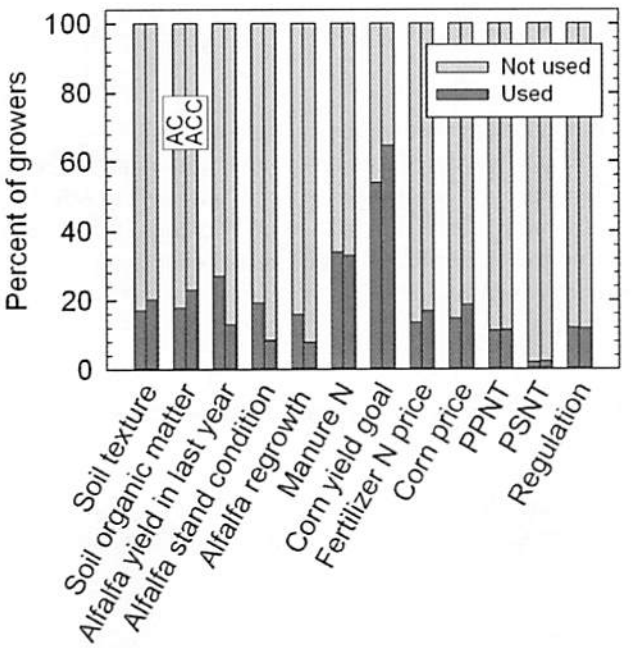

Figure 6. Factors used to determine N fertilizer rates for 421 growers with first-year corn after alfalfa (AC) and for 273 of the 421 growers with second-year corn after alfalfa (ACC). PPNT, preplant soil nitrate test; PSNT, presidedress soil nitrate test.

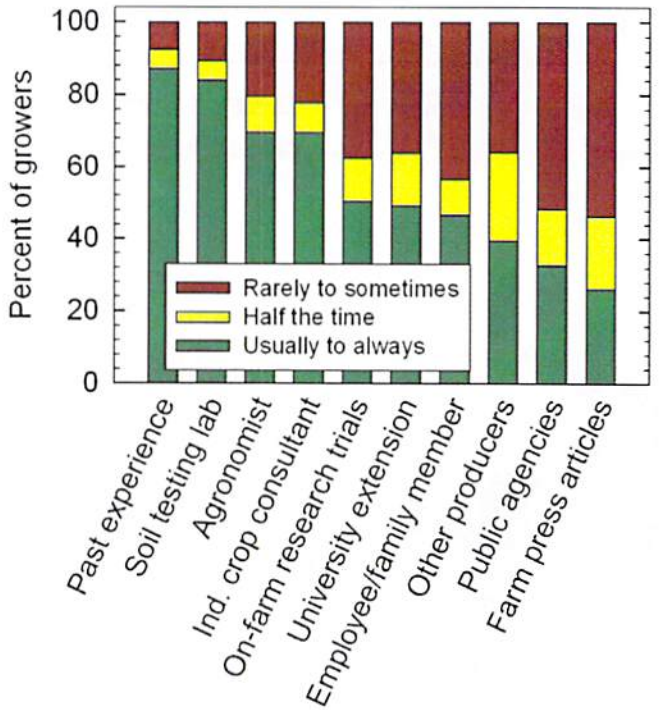

Figure 7. Perceived reliability for sources of information about fertilizer and manure N management in first- and second-year corn after alfalfa.

Conclusions:

The findings from this survey will help target future research and education on N management in corn that maximizes profit and reduces environmental impacts. These results show that several opportunities for improved N management remain. Further research and education are needed to increase adoption of alfalfa and manure N credits to first- and second-year corn. Efforts should involve multiple stakeholders and may require improved N rate guidelines for first- and second year corn after alfalfa that are more field- or site-specific.

Technical article:

Results from this grower survey are summarized in a technical article that we wrote and submitted to *Agronomy Journal* for publication:

Yost, M.A., J.A. Coulter, M.P. Russelle, and M.A. Davenport. 2014. Opportunities exist to improve alfalfa and manure nitrogen crediting in alfalfa-corn rotations. *Agronomy Journal* Submitted.

e) To accomplish the goal/objective "*Present research results to farm advisors and growers at extension meetings*," results from this research were presented to farm advisors and growers at many extension meetings and field days, including two on-farm field days that we hosted (one near Lanesboro, MN on July 16, 2012, another near Russell, MN on July 18, 2012). These two

field days were attended by attended by growers and agricultural professionals managing more than 160,000 acres. Ninety two percent of evaluation respondents at these field days said that they *agree* or *strongly agree* that they would recommend the program to others, and 50% of the evaluation respondents said that they would modify future N fertilizer management for corn after alfalfa by *much* or *very much*. Assuming that this percentage of attendees will reduce their applied or recommended N fertilizer rate for first-year corn after alfalfa by 40 lb N/acre and that this cropping system represents 5% of the cropland they manage or provide recommendations for, then these two field days alone will cause growers to reduce N fertilizer use by 161,000 lb N/year without reducing corn yield, an annual savings of $72,500 at $0.45/lb N. With this reduction in N fertilizer, energy input to corn production will be reduced by over 3.5 million megajoules/year, assuming 21.9 megajoules/lb N.

Results from this project also were presented to 40 farm advisors and growers at the Stearns County Soil and Water Conservation District Certified Crop Advisor meeting that was held in Paynesville, MN on September 5, 2012. According to the evaluations from this program, 100% of respondents reported that this presentation was *very useful* or *useful* to them. In addition, results from this research were presented to 153 growers and crop advisors at the Iowa State University Extension Integrated Crop Management Conference in Ames, IA on November 29, 2012.

Results from this research also were presented to 45 growers and farm advisors at the University of Minnesota Extension Carver County Agronomy Day in Cologne, MN on January 30, 2013, to 56 growers and farm advisors at the Midwest Forage Association Tour de Forage Meeting in Richmond, MN on February 6, 2013, and to 11 growers at the Wright/Hennepin County Corn Growers annual meeting in Buffalo, MN on March 14, 2013. The meetings in Cologne and Richmond, MN were attended by attended by growers and agricultural professionals managing more than 230,100 acres. Forty one percent of evaluation respondents at the Cologne, MN meeting and 64% of the evaluation respondents at the Richmond, MN meeting said that they would modify future N fertilizer management for corn after alfalfa by *much* or *very much*. Assuming that this percentage of attendees will reduce their applied or recommended N fertilizer rate for first-year corn after alfalfa by 40 lb N/acre and that this cropping system represents 5% of the cropland they manage or provide recommendations for, then these two meetings alone will cause growers to reduce N fertilizer use by 247,400 lb N/year without reducing corn yield, an annual savings of $111,300 at $0.45/lb N. With this reduction in N fertilizer, energy input to corn production will be reduced by over 5.4 million megajoules/year, assuming 21.9 megajoules/lb N.

In addition, a poster on this research was shared with about 200 people at the February 19, 2013 Nutrient Efficiency and Management Conference in Fergus Falls, MN, which was hosted by the Minnesota Department of Agriculture and the Minnesota Agricultural Water Resource Center. Results from this research also were presented at the University of Minnesota Southern Research and Outreach Center winter crops day in Caledonia, MN on January 15, 2014, at the Midwest Forage Association symposium in Wisconsin Dells, WI on January 21, 2014, at the University of Minnesota Extension nutrient management meeting in St. Charles, MN on February 18, 2014, and at the University of Minnesota Extension forage meeting in Kingston, MN on March 28, 2014.

f) To accomplish the goal/objective "*Present research results to farm advisors, agency personnel, educators, and researchers at the North-Central Extension-Industry Soil Fertility Conference and at the American Society of Agronomy Annual Conference*," a poster on the literature analysis at the North-Central Extension-Industry Soil Fertility Conference in Des Moines, IA on November 14-15, 2012. In addition, presentations on the literature analysis and grower survey were made at the American Society of Agronomy Annual Conference on October 22, 2012 and November 5, 2013.

g) To accomplish the goal/objective "*Conduct two specialized workshops on alfalfa nitrogen credits for farm advisors and consultants in regions with low alfalfa nitrogen credit adoption,*" a series of three winter workshops were held in central Minnesota in March of 2013. These workshops were held in Little Falls, MN on March 8, in Foley, MN on March 19, and at Melrose, MN on March 20. These winter workshops included presentations/discussions on N credits from alfalfa to corn based on the research from this project.

These three winter workshops were attended by agricultural professionals and growers managing more than 343,000 acres. All of the evaluation respondents at these winter workshops said that they agree or strongly agree that they would recommend the program to others, and 46% of the evaluation respondents said that they would modify future N fertilizer management for corn after alfalfa by much or very much. Assuming that this percentage of attendees will reduce their applied or recommended N fertilizer rate for first-year corn after alfalfa by 40 lb N/acre and that this cropping system represents 5% of the cropland they manage or provide recommendations for, then these three winter workshops alone will cause growers to reduce N fertilizer use by 315,600 lb N/year without reducing corn yield, an annual savings of $142,000 at $0.45/lb N. With this reduction in N fertilizer, energy input to corn production will be reduced by over 6.9 million megajoules/year, assuming 21.9 megajoules/lb N.

h) To accomplish and expand the goal/objective "*Obtain cropland data layer and soil type information and convert it into the necessary format for layering for geographic analysis of N management in alfalfa-corn rotations that is part of the Minnesota Agricultural Fertilizer Research and Education Council funded project titled "Improving Predictability and Adoption of Alfalfa N Credits for Corn: Part II,*" data were collected from six states (Minnesota, North Dakota, South Dakota, Nebraska, Wisconsin, and Iowa) over seven years (2006-2012) because a regional analysis will be more informative and of greater use than one focused solely on Minnesota. This objective has been completed and is explained in more detail in the annual report for April 1, 2013 to March 31, 2014 for AFREC Project R2013-A.

3.) CHALLENGES ENCOUNTERED AND LESSONS LEARNED

There were no significant challenges encountered.

4.) FINANCIAL INFORMATION

Budgeted versus actual expenses for quarters 2-4 of 2012, quarters 1-4 of 2013, and quarter 1 of 2014 are shown in Table 1. During this period, a total of $52,935 was budgeted and spent.