Optimum Nitrogen Fertilizer Management Strategies for Modern Corn Hybrids in Manitoba
Interim Annual Report to the Manitoba Corn Growers Association

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March 15, 2019

a) **Summary -** The scope of this project is addressing all four "R's" in the "4R Nutrient Stewardship" framework for N fertilization of modern corn hybrids in Manitoba: applying the right rate, at the right source, in the right place, and at the right time. In more detail, this project has the following more specific objectives:

- Determine appropriate rates for N, based on soil test reserves of N and a realistic range of yield goals for modern corn hybrids (e.g., the overall supply of N required on a per bushel basis)
- Determine the most effective and efficient combinations of timing, placement and source, especially for supplemental applications during the growing season
- Evaluate some innovative soil tests for measuring the amount of organic soil N that can be released by mineralization during the growing season
- Develop decision tools such soil testing, tissue testing and leaf colour for evaluating nitrogen sufficiency at various stages before planting and throughout the growing season.

b) **Methods -** These experiments are being conducted at two levels of intensity, gold and silver. The "gold" level sites are managed entirely by the University of Manitoba and include more treatments and measurements than for the seven "silver" level sites, which are hosted within commercial corn growers' fields. Detailed methods for each level of experiment are provided in the attachment.

c) **Progress during the reporting period and d) Project Progress to date -** The first year of field trials has been completed two gold sites and seven silver sites (one more silver site than originally planned for). The plant and soil samples have recently been chemically analyzed and the results of those analyses and the yield measurements are being statistically analyzed. Preliminary observations for the project are summarized in the attached poster.

Overall, corn grain yield in 2018 was limited by inadequate moisture at many of the field sites, with maximum yields ranging between 90 and 165 bu/acre. In addition, one of the silver sites (near Elgin) was damaged by a hail storm in June. Wet and cold weather during late fall delayed harvest of the plots and also delayed and prevented some of the soil sampling that was planned for. Therefore, the several sites were not fully soil sampled to 4 ft deep for every plot after harvest, as planned for.

Although another year of field trials will be conducted, early trends are:

- Enhanced efficiency fertilizers regularly increased yield over urea
- Split application did not increase yield and may have decreased yield in some situations
- Low soil nitrate levels affected yield differently between sites, depending on the soil's capacity to mineralize additional N from soil organic matter
- Economic optimum rates for fertilizer N were never greater than 120 lb N per acre

e) **Extension and Communication Activities -** interim results for the project have been presented through a poster presented at the Manitoba Soil Science Society meeting in February 2019. Please refer to attached "handout" version of the poster.

f) **Financial and Other Administrative Aspects -** So far, the project seems to be within its original budget. The University of Manitoba Budgets and Grants Office will provide a comprehensive financial statement that summarizes the total income and expenditures to date for this research grant. They will also provide invoices to the MCGA.

Equipment bought - no major pieces of equipment have been purchased with this grant. Although a reflectance meter was planned for in the original budget, we are collaborating with partners (Mario Tenuta and Paul Bullock) who are providing that equipment.

Personnel involved - Lanny Gardiner, M.Sc. student, has been supported by this research grant and he will continue to be supported by this research grant over the next year. In addition, these grants have supported a summer student, Kelly McDougall, who worked on this project during the summer of 2018. Another part-time student technician, Mackenzie Booker, was hired to help collect and process corn and soil samples in late fall and early winter and another summer student will be hired for the summer of 2019.

Project materials developed - as stated above, interim results for the project have been presented through a poster presented at the Manitoba Soil Science Society meeting in February 2019. Please refer to attached "handout" version of the poster. The principles of the project were also illustrated at Crops-A-Palooza in Portage in July and the project, itself, was featured in a Top Crop Manager article in December (see attached).

Please note that in addition to the funding provided by the MCGA, the project is being supported by a grant from Nutrien (formerly Agrium). That funding is being used to support additional activities or purchases outside the scope of the MCGA grant. For example, the additional funding from Nutrien will be used to pay if extra analytical costs are incurred for extra sites, as well as to install additional parts on our plot combine to improve its performance for harvesting corn. The Nutrient funds are also used to support opportunities for enriching the students' experience by sending them to workshops and conferences.

Optimum Nitrogen Fertilizer Management Strategies for Modern Corn Hybrids in Manitoba

Summary of Research Project Sponsored by the Manitoba Corn Growers Association

Don Flaten, Dept. of Soil Science, Univ. of Manitoba

March 15, 2019

This document provides an initial draft of a research proposal to update the N fertilizer recommendations for grain corn production in Manitoba. Although the proposal has been aimed at the Manitoba Corn Growers Association, we would also propose to ask for funding from other public and private organizations to support this two-year project that will explore the most appropriate rates, sources, timings and placements for N fertilization of modern corn hybrids in Manitoba. The research project is intended to be conducted jointly with an on-farm testing project that will be led by John Heard, Crop Nutrition Specialist with Manitoba Agriculture. A brief description of the on-farm testing project is provided for information, only.

Background and Rationale for the Study

The scope of this project is meant to address all four "R's" in the "4R Nutrient Stewardship" framework for N fertilization of modern corn hybrids in Manitoba: applying the right rate, at the right source, in the right place, and at the right time. A summary of the background for each of these management factors is as follows.

N Rates - Manitoba farmers are planting corn hybrids with much greater yield potential than when the last corn N fertilization trials were conducted by the University of Manitoba almost 35 years ago (Soper et al. Agro-Man Project 208 Fertilization for special crops (1981-1983)). Studies in the US have shown that today's high yielding hybrids are much more efficient than old hybrids with respect to nitrogen use efficiency, ie. that modern corn hybrids produce more grain per lb of N than old hybrids (eg. Woli et al. 2016). We hypothesize that similar improvements in nitrogen use efficiency have reduced the N requirements per bushel of grain yield for modern corn hybrids grown in Manitoba.

Examples of N rate recommendations currently available for Manitoba's corn growers include:

- The Manitoba Soil Fertility Guide (2007) provides N recommendations for corn target yields as high as 130 bu/ac, which is less than the yields currently achieved by some corn growers in Manitoba. To grow 130 bu/ac on a field with 30 lb of residual nitrate-N per acre, the Soil Fertility Guide would recommend **195** lb fertilizer N/acre or a total N supply from soil and fertilizer of **1.7** lb N per bushel of corn.
- The guide to Corn Production in Manitoba (2004) also provides N recommendations for corn target yields as high as 130 bu/ac. To grow 130 bu/ac on a field with 30 lb of residual nitrate-N per acre, the Soil Fertility Guide would recommend **225** lb fertilizer N/acre or a total N supply of **2.0** lb N per bushel of corn.
- The Agvise soil testing lab in North Dakota provides N recommendations for corn target yields as high as 240 bu/ac. To grow 130 bu/ac on a field with 30 lb of residual nitrate-N per acre, Agvise recommends **156** lb fertilizer N/acre or a total N supply of **1.2** lb N per bushel of corn.
- NDSU's new guidelines are divided by area and yield potential within their state; the guidelines are also affected by tillage system, soil organic matter, and prices for crop and fertilizer. For a situation such as the Eastern region of ND, which likely applies to most of MB, a 130 bu/ac crop (which is less than the 160 bu/ac average yield category), corn priced at US $3/bu and fertilizer N at US $0.30/lb on land with 30 lb of residual N, would receive a recommendation for **120** lb of fertilizer N/acre or a total N supply of **1.15** lb N per bushel of corn.

In summary, Manitoba's current recommendations of almost 2 lb N/bu of corn target yield are much higher than recommendations from other sources. This high recommendation represents a large financial risk to corn growers, as well as substantial agronomic and environmental risks (eg. excess leaching and greenhouse gas emissions).

N Sources - Fertilizer technology has advanced considerably since the latest fertility research was conducted with corn in Manitoba. For example, corn growers have access to fertilizer additives such as urease inhibitors (eg. Agrotain) or fertilizers that include urease inhibitors (eg. Super U) that stabilize broadcast applications of urea, to reduce ammonia volatilization losses. They also have more options for nitrification inhibitors (eg. eNtrench, Super U, and N-Serve) that can help to reduce N losses by leaching and denitrification.

N Timings and Placements - Fertilization application techniques have also changed. With high clearance sprayers common on or available to many farms in Manitoba, corn growers have the opportunity to apply liquid N relatively late in the growing season, when yield potential is more predictable and when risk of early season losses due to excess moisture have diminished. However, even though midseason fertilization might be regarded as a means of reducing N losses, research in the Prairies with barley and wheat has shown that there is a substantial risk of midseason N being "stranded" on the soil surface if the weather is dry for an extended period after the N is applied.

If N is applied during the growing season, there are two main options to consider:

- sidedress in the early vegetative phase (V4), when the corn is 1-1.5 ft tall, as a subsurface band applied using a tool bar (eg. with anhydrous ammonia, urea or liquid UAN fertilizer)
- surface band later in the season (V6) in the form of UAN liquid fertilizer, applied with a high clearance sprayer. Especially at this stage, many agronomists would prefer to recommend applying N in "dribble bands" from hoses that drop through the foliage (eg. Y-drop) to minimize leaf burning and to maximize efficiency of fertilizer N uptake from the soil.

To address these issues, the 4Rs (Right Rate, Source, Placement and Timing) approach for nutrient management must be determined for these new, high-yielding corn hybrids, with the following more detailed objectives:

- Determine appropriate rates for N, based on soil test reserves of N and a realistic range of yield goals for modern corn hybrids (e.g., the overall supply of N required on a per bushel basis)
- Determine the most effective and efficient combinations of timing, placement and source, especially for supplemental applications during the growing season
- Evaluate some innovative soil tests for measuring the amount of organic soil N that can be released by mineralization during the growing season
- Develop decision tools such soil testing, tissue testing and leaf colour for evaluating nitrogen sufficiency at various stages before planting and throughout the growing season.

In total, three levels of field experiments, tests, and demonstrations are proposed to address these challenges. In all cases, plots would be grown using management practices for high yields. Overall leadership and project coordination will be provided by scientists at the U of M (Don Flaten and others) in collaboration with MAFRD (John Heard).

Experimental Methods

Field experiments are proposed for two growing seasons, 2018 and 2019. The three levels of experiments include the following, keeping in mind that the on-farm "bronze" level experiments will be led by John Heard, from Manitoba Agriculture, and are presented for information only.

Data analyses will focus on the determining the agronomically and economically optimum combinations of:

- soil plus fertilizer N on a per bushel of grain basis (N rate)
- conventional and enhanced efficiency fertilizers (N source)
- as well as the optimum combination of N applied before planting, immediately after planting and at midseason (N timing and placement).

1. Gold level intensive, small plot research experiments fully managed by the University of Manitoba - The experiments hosted by the U of M on loam soils near Carman and on clay soils near Winnipeg would be more complex and intensive than those at the "silver" and "bronze" levels that are (please refer to "gold" level in Table 1). In summary, one modern corn hybrid will be grown, selected for high yield potential and a reasonably high probability of maturing in Manitoba. Treatments will include the following:

a) Rates of N applied at planting will be 40, 80, 120, 160 and 200 lb N/acre, similar to those for the "silver" level experiments on commercial corn fields, except that for the "gold" experiments, the fertilizer will be applied as broadcast conventional urea, incorporated prior to planting (6 treatments)

b) In addition, the "gold" experiments will include preplant broadcast and incorporated applications of "enhanced efficiency fertilizers" including Super U (which includes a urease and a nitrification inhibitor), a 50:50 blend of conventional urea and ESN (polymer coated urea fertilizer), and conventional urea treated with eNtrench (a nitrification inhibitory) at the 80 and 120 lb N/acre rates (6 treatments)

c) Immediately after planting, Super U will be broadcast without incorporation at rates of 40, 80 and 120 lb N/acre, to match the source and placement used on commercial corn fields for the "silver" level experiments (3 treatments)

d) Midseason applications of 40 and 80 lb N/acre will be applied on plots where 40 lbs N/acre was applied immediately after planting, for a total application of 80 and 120 lb N/acre. All midseason applications will be applied as UAN liquid fertilizer, either side-dressed on its own as a subsurface band at V4, or surface dribbled with and without Agrotain urease inhibitor at V6 (6 treatments)

e) Soil supplies of nitrate-N will be measured at planting, pre-side-dress and at maturity. Measurements of soil N at planting will also include estimates of mineralizable organic N in soil, using spectroscopic absorbance at 205 nM for $NaHCO_3$ extraction (Sharifi et al 2014) and Les Henry's field-moist soil incubation test. Midseason assessments will include Greenseeker and SPAD or Rapidscan measurements of leaf reflectance. At harvest, crop measurements will include grain yield and N content, as well as stalk nitrate content. Growing season rainfall will be measured as well as soil moisture content at planting and harvest.

2. Silver level research small plot research experiments conducted on commercial corn fields, in collaboration with corn growers – Six commercial corn growers will be invited to host "silver" level tests on their own fields (Table 1). These tests are less intensive than the U of M tests, with fewer treatments (eg. with a smaller number of N sources and placements, due to the inability to set up preplant broadcast treatments). Therefore, this group of experiments will be intermediate in intensity, between those for the on-farm tests and those fully managed by the University of Manitoba. For the "silver" experiments, the rates of N applied at planting will be the same as those for the "gold" experiments (1 a)), except that all N will be broadcasted as Super U, immediately after planting (6 treatments). Midseason applications of N will

be the same as in 1 d) for the "gold" experiments (6 treatments). Measurements will also be similar to those for the "gold" experiments (1 e)).

3. Bronze level on-farm tests (for information only - to be funded and conducted separately) – Corn growers, agronomists and crop supply retailers will be recruited by John Heard and others in Manitoba Agriculture to conduct "bronze" level tests (Table 1). These tests are much simpler than the small plot trials and would typically include commercial scale field tests of a two treatments aimed at comparing levels of one nutrient management factor, eg. comparing two N rates, or two N sources, or two N timings. All on-farm tests will be replicated.

Table 1. Proposed framework for three levels of treatments and measurements for determining optimum N management strategies for high yielding modern corn hybrids in Manitoba

	Treatments			Measurements		
Level	**N Rates (lb N/ac)**	**Sources**	**Timings-Placements**	**At Planting**	**Midseason**	**Harvest**
Gold Established and maintained by U of MB	Check (Zero N) Fert N = 40 Fert N = 80 Fert N = 120 Fert N = 160 Fert N = 200 … plus midseason of 40 (suboptimal?) or 80 (optimal?) in addition to the 40 at planting	Broadcast conventional urea before planting for all rates; also b'cast preplant Super U, eNtrench-treated urea and 1:1 urea:ESN blend at 80 & 120 lb N/ac rates; also b'cast Super U immediately after planting (to match Silver protocol) at **40,** 80 & 120 N rates, plus UAN side-dressed at V4 and surface dribble band UAN and UAN+Agrotain at V6 at 40 and 80 in addition to 40 **lb N/ac as SuperU** that was b'cast immediately after planting (total N applied @40+40=80 and 40+80=120)		Soil nitrate-N & sulphate-S (0-120 cm), mineralizable N ($NaHCO_3$ absorbance & Les Henry field-moist soil incubation), Olsen P, Exch K, DTPA Cu Zn, pH, EC, SOM (0-15 cm), gravimetric soil moisture to 120 cm, composited by rep	Sample soil to 12" for Pre-Side-Dress Nitrate-N test; Greenseeker and SPAD or HS Rapidscan (Crop Circle), tissue N?, growing season rainfall. UAV flights.	Grain Yield, Grain N (for N uptake only), Late Season Stalk Nitrate Test & Residual nitrate-N (0-120 cm, as auditing tools), gravimetric soil moisture to 120 cm
Silver Small plot trials applied after planting on unfertilized areas of commercial farm fields	Check (Zero N) Fert N = 40 Fert N = 80 Fert N = 120 Fert N = 160 Fert N = 200 … plus midseason of 40 (suboptimal?) or 80 (optimal?) in addition to the 40 at planting	Broadcast Super U immediately after planting for all 6 rates; side-dress UAN at V4 and surface dribble band UAN and UAN+Agrotain at V6 at 40 and 80 lb N/ac in addition to 40 **lb N/ac as SuperU** that was b'cast immediately after planting (total N applied @40+40=80 and 40+80=120)		Soil nitrate-N & sulphate-S (0-120 cm), mineralizable N ($NaHCO_3$ absorbance & Les Henry field-moist soil incubation), Olsen P, Exch K, DTPA Cu Zn, pH, EC, SOM (0-15 cm), gravimetric soil moisture to 120 cm, composited by rep	Sample soil to 12" for Pre-Side-Dress Nitrate-N test; Greenseeker and SPAD or HS Rapidscan (Crop Circle), tissue N?, growing season rainfall. UAV flights.	Grain Yield, Grain N (for N uptake only), Late Season Stalk Nitrate Test & Residual nitrate-N (0-120 cm, as auditing tools), gravimetric soil moisture to 120 cm
Bronze On-Farm Tests	Producers would select one of several options for On Farm Tests such as: 1) rate - base rate of N plus and/or minus 40, all at planting; 2) source - base rate of conventional vs. enhanced efficiency N fertilizer sources (eg. N-Serve/Entrench, Super U, or 50% ESN) applied at or before planting; 3) timing - base rate vs. base rate minus 40 at planting and replacing with 40 applied in midseason at V4 (side-dress) or V6 (Y drop)			Soil nitrate-N & sulphate-S (0-60 cm), Olsen P, Exch K, Cu, DTPA Cu Zn, pH, EC, SOM (0-15 cm)	Sample soil to 12" for Pre-Side-Dress Nitrate-N test; Greenseeker (no SPAD), tissue N? and UAV flight	Grain Yield, Late Season Stalk Nitrate Test

Optimum Nitrogen Fertilizer Management Strategies for Modern Corn Hybrids in Manitoba

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Background

Genetic improvements, rising input costs, advancements in technology, and environmental concerns have pushed for the further development of beneficial management practices for nitrogen (N) fertilization. As with most crops in Manitoba, corn has a large requirement for nitrogen, meaning that suboptimal rates will reduce yield. However, excessive application rates are an unnecessary expense for farmers and present risks to the environment. Corn production in Manitoba has increased substantially in recent years, while the last corn nitrogen research was conducted over 35 years ago. The goal of this research is to meet producers questions with scientific knowledge and recommendations.

Location	Spring NO_3^- N (lb/ac 0-24in)	Mean Yield Check Plots (bu/ac)
Stephenfield (Step)	37	35
MacGregor (Mac)	48	73
Winkler (Win)	52	89
Carberry (Car)	55	47
Carman W (Owe)	64	104
Carman S (Kost)	80	107
Portage (Por)	91	91
Rosebank (Rose)	110	112
Elgin (Elg)	130	114

0 N
Stephenfield 2018
200 lb/ac N

Methods

- 17 site years of studies over 2 seasons across Manitoba
- 6 rates used from 0-200 lb/ac N
- 6 nitrogen sources/ inhibitors
- 4 application timings
- 4 placements

Soil Measurements:
- Pre-plant nutrient analysis
- Soil moisture
- Pre-side dress nitrate test
- Post harvest nitrate
- Texture characterization
- Estimate mineralizable N

Plant Measurements:
- Leaf reflectance via Crop Circle, Greenseeker and drone NDVI
- N deficiency ratings
- Grain yield, moisture & nitrogen content
- Biomass yield & nitrogen content, stalk nitrate content

Other Measurements:
- Rainfall, temperature

Preliminary Results

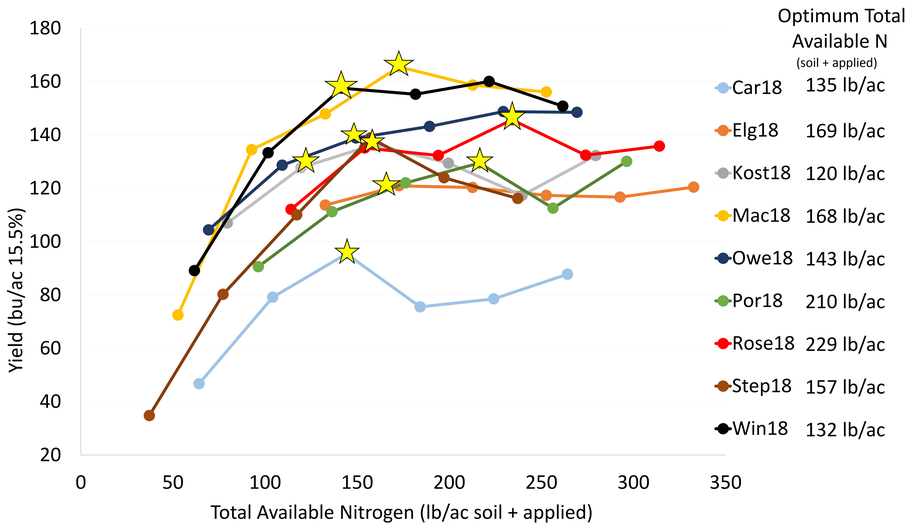

Figure 2. Mean yield of nitrogen rate treatments at each 2018 site. Stars indicate most profitable rate of N at each site.

Early trends are
- Enhanced efficiency fertilizers regularly increase yield over urea
- Split application does not increase yield, may sacrifice yield in situations
- Low soil nitrate levels affect yield differently between sites
- Optimum rate to apply fertilizer was never greater than 120 lb/ac N

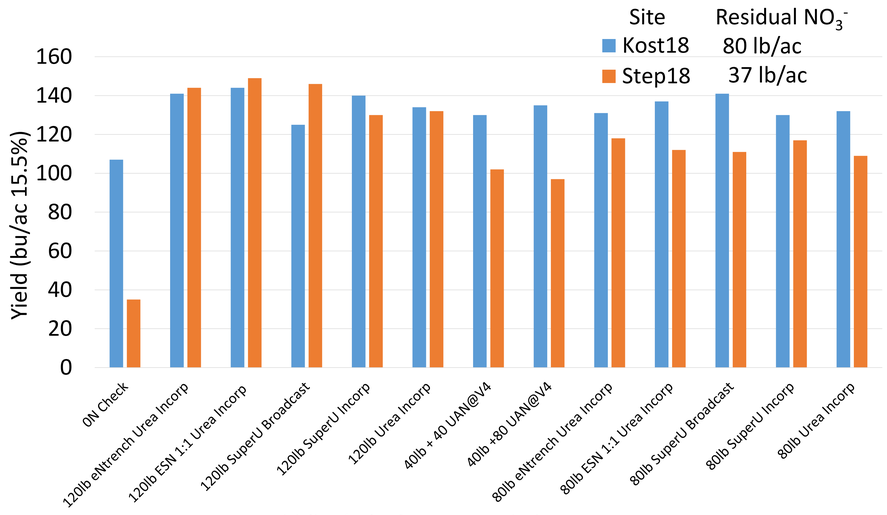

Figure 3. Yield (bu/ac) of source and placement treatments at 80 & 120 lb/ac N rate

2018 was a dry year; this is not ideal for fertility research because maximum yield potential of the crop was not reached. This means that there was reduced plant demand for nitrogen; as well, dry soil inhibits the mobility of nitrogen and is therefore less accessible by roots.

However, a year like 2018 can help us to evaluate the benefits of inhibited nitrogen products and split application when used in situations that have low risk for leaching and denitrification. A dry year can also help to evaluate the benefits of split application, a management practice that is usually designed to mitigate losses and increase N efficiency during growing seasons with increased rainfall.

Plans for Additional Research

With one more season of research to go I am still looking for sites within a corn field with relatively low residual nitrate. Please contact me if interested in hosting one.

Sample processing and analyses are still underway; these analyses will allow for a greater understanding of the nitrogen dynamics for each treatment. Evaluating the grain and stalk nitrogen concentration means a more precise determination of which plots were sufficiently supplied with N. This is useful for trying to reduce excess post season soil nitrogen and characterize the mineralization occurring at each site.

A more in depth statistical analysis is to be completed.

In-season data was collected using various methods to characterize the nitrogen status of the plant and predict N needs to maturity. With all the data we hope to improve the overall precision of these tools by providing calibrations for corn grown on Manitoba soils.

Acknowledgements & Contact

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PHOTOS COURTESY OF DON FLATEN.

FIGURING OUT NITROGEN FOR CORNY YIELDS

There are many ways to manage nitrogen.

by Bruce Barker

Two hundred bushels of corn without any nitrogen (N) fertilizer? That happened in 2016 at St. Adolphe, Man., and is one of the more surprising results of a Manitoba Agriculture research trial.

"Some soils have huge nitrogen mineralization. Unfortunately to date we've not been able to predict it, even based on organic matter content," says John Heard, a soil fertility specialist based in Carman, Man.

Heard has been conducting nitrogen trials on corn for many years. In 2018, the University of Manitoba under the direction of soil scientist Don Flaten with masters' student Lanny Gardiner started a two-year trial looking at all four factors in the 4R Nutrient Stewardship program – rate, source, timing and placement. Mario Tenuta at the university is also conducting an intensive corn N fertilization study looking at greenhouse gas emissions at a few sites across Canada including one in Manitoba.

"The previous nitrogen recommendations for corn in Manitoba were outdated, and there was some contradictory information on how much nitrogen is needed to produce a bushel of corn," Flaten says.

The last N research done at the University of Manitoba was in 1981 through 1983, and the Manitoba Soil Fertility Guide (2007) and the Guide to Corn Production in Manitoba (2004) publications have top yield targets of 130 bushels per acre – numbers that now feel outdated when corn yields in Manitoba now hit 200 bushels per acre or more in some areas.

The nitrogen recommendations for a 130 bushel per acre corn crop with a soil test of 30 pounds per acre are 195 pounds of nitrogen (lbs. N) from the Manitoba Fertility Guide and 225 pounds per N from the Guide to Corn Production. Those rates mean 1.7 to two lbs. N uptake per bushel of corn. For a 200-bushel corn crop, these recommendations would suggest 340 to 400 lbs. N per acre is required.

ABOVE: **John Heard (Manitoba Agriculture Crop Nutrition Specialist), Jeremy Gladish (U of M summer student), Lanny Gardiner (U of M masters' student) and Kelly McDougall (U of M summer student) in a research plot that did not receive N fertilizer near Stephenfield, Man.**

However, rate recommendations are changing. North Dakota State University recommends 1.15 pounds total N per bushel for eastern North Dakota. AgVise Laboratories, with laboratories at Northwood, ND and Benson, MN, recommend 1.2 pounds total N per bushel.

"This shouldn't be a surprise to any of us. Farmers have been doing a better job of nitrogen placement and timing, so more fertilizer N is available to the crop," Heard says. "With the high yield potential, nitrogen use efficiency of corn has improved as well."

Flaten also says that there is evidence that corn may be over-fertilized. Soil nitrate-N from soil test data after harvest shows that the amount of nitrate-N left over after a wheat crop is 24 to 45 pounds per acre, but 56 to 61 pounds per acre after corn. The amount of nitrate-N left after corn can be double the amount left by a wheat crop.

"I think there are opportunities to fine-tune nitrogen recommendations," Flaten says. "If we are over-fertilizing corn, it is more expensive and has more environmental risk."

The U of M research is looking at many aspects of the 4Rs. Rate treatments range from zero to 200 pounds per acre. Sources include urea, UAN, and enhanced efficiency fertilizers alone and in a blend with urea or as UAN. Timing and placement include pre-plant broadcast, post-plant broadcast, and split applications of pre-plant and V4 or V6.

The research is also hoping to develop a better way to estimate mineralization and to develop decision tools for in-season applications. Funding is coming from the Manitoba Corn Growers Association and Nutrien.

Right rate

While the U of M research won't have recommendations until after the 2019 growing season, Heard's field research over the past few years provides guidance in the interim. His research in 2016 and 2017 at 10 sites compared six nitrogen rates of surface broadcast SuperU (zero, 40, 80, 120, 160 and 200 lbs. N/ac.) Additional treatments included split N application of 40 to 80 lbs. N/ac as surface dribbled UAN at V4 to V8 stages.

The most economical rate of nitrogen (MERN) was calculated using four dollars per bushel corn and $0.40 per pound of N. For three medium yielding sites with yield between 100 to 150 bushels per acre, the MERN was 150 pounds total soil and fertilizer N per acre, and was achieved with about 1.2 pounds total N per bushel. For high yielding sites between 150 to 200 bushels per acre, MERN was 182 pounds total soil and fertilizer N per acre and about 0.95 pounds total N per bushel.

Very high yields were achieved at many sites even without applied N. Estimated mineralization was 150 lbs. N per acre or more at six of 10 sites, which Heard says is about three times greater than traditional estimates. To find out if organic matter content could be used to predict mineralized N, he plotted estimated mineralized N against organic matter content of the soils and found they were poorly correlated.

"There is a tremendous amount of mineralization in row crop corn production systems. The nitrate-N soil test doesn't account for it, so we need better tools for predicting mineralized N," Heard says.

Heard mentioned that the agricultural industry is actively developing decision tools that may help estimate in-season

Previous nitrogen recommendations for corn in Manitoba are outdated, so a team is now looking to update guidelines based on the 4R Nutrient Stewardship program and other factors.

mineralization and losses. These include tools from Climate Corporation, Adapt-N from Cornell University, Farmers Edge's FarmCommand and N Manager, and Encirca from Corteva, but remain untested by public research in Manitoba.

Right timing and placement

Grower surveys in Manitoba, indicate that about one-third of farmers apply all their nitrogen in the fall, usually as anhydrous ammonia; another one-third as broadcast urea mostly pre-seed; and the last one-third splitting application between pre-seed and in-season.

Since corn N uptake is continuous from emergence to grain fill, Heard says there are opportunities to split N fertilizer application between seeding with an in-crop band. In his research, UAN was sidebanded with a Y-drop applicator that directed the dribbleband to both sides of the corn plant. The results found that at N responsive sites with fertilizer N of 40 lbs. N per acre or more, yield was similar between broadcast N at seeding and split applications at the V4 and V8 stages.

On-farm trials conducted by the Manitoba Corn Growers Association found similar results with split applications in 2017. These nine trials in the Red River Valley compared the farmer's base application rate of N fertilizer at seeding compared to the base rate less 40 pounds plus a sidedress application of 40 lbs. N as UAN between V4 and V6. Application timing of sidedress UAN at one site was V8. UAN was applied with various methods including Y-drop, streamed, coulter injected and broadcast.

On average, there was no difference between the spring-applied base N and the split N application in 2017. The sidedress application at V8 had lower yield, attributed to the dry conditions where N uptake was possibly restricted.

"In the U.S. corn belt, in-season N application is common because of their wet growing season. A lot of land has tile drainage and if all the N fertilizer was put on at seeding, there would be leaching losses," Flaten says. "In Western Canada, we don't have the same degree of leaching risk. With our high level of mineralization, we have more cases of 'appearance' of N during the growing season than 'disappearance.'"

The other challenge for split application is stranding of the dribble band or broadcast N on the soil surface during a dry growing season. Guy Lafond's research on split N applications on wheat at Agriculture and Agri-Food Canada in Indian Head, Sask. found that it worked two out of three years, but dryness in the third year resulted in stranding of N on the soil surface and lower yield.

"There is a grower fascination with late season split application. It is a different way to apply nitrogen, but not necessarily a better way," Heard says.

Right source

Heard has also looked at the enhanced efficiency fertilizer ESN that helps to reduce leaching or nitrate oxide losses under wet conditions. He found that in very wet years the enhanced efficiency fertilizers produced higher yields than urea but not in dry or normal rainfall years.

"Enhanced efficiency fertilizers don't increase yield but protect yield that could be lost because of nitrogen losses," Heard says. "You probably wouldn't have lost much N in 2017 or 2018 because it was dry, unless you surface broadcast urea without incorporation which would have resulted in volatilization losses."

Heard says enhanced efficiency fertilizers allow growers to manage the risk of N losses. The decision to use an enhanced efficiency fertilizer depends on a corn grower's individual circumstance, such as their equipment capabilities, labour constraints, soil type and risk tolerance. For example, fall N application or spring broadcast application before seeding helps to spread out the workload – so a grower might choose to use an enhanced efficiency product. In contrast, another grower might manage potential N losses through split applications to allow in-season assessment of yield potential.

"Dr. Emerson Nafziger, from the University of Illinois, has said there are 21 ways to supply 150 pounds of N to corn. We have opportunities to fine-tune our application strategies so agronomists and growers can adapt them to their individual circumstances," Heard says.