RESEARCH DIRECTORY 2018

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This publication provides an overview of research projects jointly funded by the Minnesota Corn Growers Association (MCGA) and the Minnesota Corn Research & Promotion Council (MCR&PC) through the Minnesota corn check-off.

The corn check-off, self-funded by corn farmers themselves, supports research that investigates the development of value-added products, the management of corn inputs, topics related to ethanol use, the evaluation of genetic traits, and the relationship between agricultural management practices and water quality.

Included in this research portfolio are projects that promote the success of Minnesota corn farmers, their families, and Minnesota's rural economy.

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Hyperthermostable Enzyme (Lactonases) for Use as Microbial Biocontrol Agents for Plant Diseases (2017)

University/Company: University of Minnesota
Principle Investigator: Michael Sadowsky

Numerous bacterial pathogens infect crop plants, representing major economic burdens, and limit our ability to feed the world's populations. Current methods for controlling plant diseases due to bacterial infection have had limited success, in part, due to bacterial resistance and specificity. Novel strategies are, therefore, greatly needed to control microbes.

Numerous bacterial pathogens use chemical signaling systems to coordinate virulence factor expression and biofilm formation. A common bacterial communication mechanism called quorum sensing (QS) regulates bacterial gene expression in response to fluctuations in cell density. A common class of QS molecules are acyl homoserine lactones (AHLs). The hydrolysis of AHLs lead to the disruption of bacterial communication, and a subsequent reduction of biofilm formation and virulence. Therefore, the use of a controlled biologically-derived agent, for example, a lactonase preparation, to control plant pathogens, is appealing.

Our group has isolated and engineered enzymes that are highly proficient and extremely stable, can be used as biocontrol agents, and can be active at all times, independently of the ecosystem. We propose to use these unique molecules and examine their potential to protect a variety of plants, including corn, from infection, and examine their ability to reduce post-harvest damage to crops during storage.

Historical Assessment of Improvement in Management Practices Associated with Corn Production (2018)

University/Company: University of Minnesota
Principle Investigator: David Mulla

Corporate supply chain, commodity production group, government farm and environmental protection agency and societal forces have stimulated the development of a wide range of assessment tools to determine the sustainability of farming practices. These efforts are being led nationally by Field to Market, a consortium of multinational agribusiness, commodity groups, and academic and non-governmental entities. Field to Market has used a Science Advisory Board to develop the FieldPrint® Calculator for the assessment of farm sustainability (with a focus on energy use, greenhouse gases, land use, soil conservation, irrigation use and water quality).

In Minnesota, the Department of Agriculture (MDA) spearheaded an effort to develop the Minnesota Agricultural Water Quality Certification Program (MAWQCP). MAWQCP is based on physical characteristics affecting soil loss, as well as nutrient management, tillage management, pest management, irrigation and drainage management and other conservation management practices.

Both the FieldPrint and MAWQCP tools are voluntary. Their use is designed to help producers receive recognition for the beneficial practices they use, to help provide greater access to sustainably sourced markets, to provide protection from regulation, and to provide technical assistance for improving farm management.

There is no established long-term historical assessment of sustainability with any of these new sustainability efforts. A pressing need exists to identify historical trends in management practices to identify how much progress has been made to improve the sustainability of farms.

The goal of this project is to conduct a historical assessment of changes in management practices used by Minnesota corn producers covering at least the last 25 years at five- to ten-year intervals. This assessment will be used to identify management practices that have improved and to identify strategies for further improvement. The assessment will also identify which management practices are difficult to track and identify historical trends.

Soil Health Partnership Farm Network (2018)

University/Company: Soil Health Partnership/ National Corn Growers Association
Principle Investigator: Nick Goeser

This project is to fund four additional sites across Minnesota as part of the Soil Health Partnership (SHP) network. The vision of SHP is to demonstrate the research-supported value of soil health to agricultural productivity, profitability, and environmental sustainability, through a continual awareness of and investment in soil health by farmers, consumers, policy makers, the private sector and non-profit organizations.

SHP is a farmer-led initiative fostering transformation in agriculture through improved soil health, benefiting both farmer profitability and the environment. Established in 2014 by the National Corn Growers Association (NCGA), a network of working farms has been built where advanced farm management practices that will enhance sustainability and farm economics for future generations are tested, measured and the results then shared with farmers and the non-farming public. Long-term data on working farms is collected in real growing conditions, and that data is used to mentor farmers.

Our primary objectives are: build a robust Farm Network of over 100 farms across 12 states, including the Greater Mississippi River Basin, the Great Lakes Basin, and the Chesapeake Bay Watershed; generate data using scientific protocols for standardized research methodology commissioned by a Scientific Advisory Council; employ sustainability metrics, outcome tracking, and generate updated, science-based Best Management Practices (BMP's) recommendations and peer-reviewed publications; leverage state and national outreach, and drive increased awareness among thought leaders on the impact of improving soil health to agriculture and the environment.

Farmable Vegetative Buffers (2018)

University/Company: United States Department of Agriculture-Agricultural Research Service
Principle Investigator: John Baker

The overall objective of this project is to develop and test management practices that will establish perennial vegetative buffers that can sustain row crop production within them. Specific objectives include development of data-driven guidelines for nitrogen (N) management in corn/kura clover living mulch systems; compare the performance of kura clover and Kentucky Bluegrass as perennial living mulches for corn production; develop and test methods to promote faster establishment of kura clover; and field demonstrate living mulch systems as vegetative buffers.

Phosphorus (P), potassium (K), sulfur (S), and micronutrients will be applied to the entire area if needed, based on soil test recommendations. Plots will be zone tilled prior to planting and urea and ammonium nitrate fertilizer (UAN) will be applied at five rates: 25, 50, 100, 150 kg ha-1 and a control (no N). Plots will be inspected weekly for weeds and pests. As was done in previous work, soil inorganic nitrogen will be measured throughout the growing season to a depth of 15 cm to monitor nitrogen additions from the living mulch during spring management.

The Soil Plant Analysis Development (SPAD) chlorophyll meter will be used as an in-season plant nitrogen monitoring tool that strongly relates leaf chlorophyll content to plant nitrogen content and end-of-season yield. Sampling at the physiological maturity stage of kura clover, stover, cobs, and grain, as well as subsamples of each, will be conducted in each plot and analyzed for total nitrogen on combustion.

Residual soil nitrate to a depth of 60cm will be quantified to determine its relationship with fertilizer additions. An economic analysis of corn production profitability within the living mulch system will also be compared to conventional corn systems. In addition, methods for establishing kura clover living mulch will be evaluated, with a specific goal of determining the benefit, if any, of N fertilizer in kura clover establishment.

Maximizing Soil Warming and Health Under Different Tillage Practices in a Corn-Soybean Rotation (2018)

University/Company: University of Minnesota
Principle Investigator: Jodi DeJong-Hughes

Advantages to a reduction in tillage can include improved aggregation and water infiltration, reduced soil loss, increased organic matter content, biological populations, and diversity in the soil. However, concern about yield reductions due to cool and wet soil conditions may limit adoption of reduced-tillage systems for corn-soybean rotations on the poorly-drained soils that dominate much of Western Minnesota and North Dakota.

Soil tillage benefits crop production by decreasing soil density and, thus, aerating the soil and reducing soil strength. Both benefit germination and root development. However, tillage types vary in how this decrease in density is accomplished (i.e. overturning, fracturing, etc. the soil) and the effectiveness for benefitting seed germination, seedling emergence, and root development. Tillage can also decrease incidence and severity of root diseases that tend to be less common in drier and warmer soils. Conversely, tillage can potentially increase root diseases that are favored by warmer soils.

Tillage practices allow an increased rate of soil warming due to: 1) lowering soil moisture content and reducing solid-soil particle contact points, which otherwise would conduct greater quantities of heat deep into the soil profile away from the seedbed, and 2) decreasing soil residue cover allowing soil to absorb greater quantities of solar radiation. Since tillage types vary in how they decrease soil density, the rate of soil warming is expected to vary with tillage type.

However, these rates of soil warming due to tillage type are expected to be impacted by water table management practices and residue levels. Subsurface drainage aerates topsoil by continuously lowering the water table to a designated depth (i.e. 0.61 to 1.22 m). This decrease in soil moisture may allow for greater rates of soil warming near the soil surface. Consequently, differences between soil tillage on the rate of soil warming would be expected to be buffered by the presence of subsurface drainage water table management.

The ultimate goal of this project is to improve corn yields (and soybean) while at the same time building soil health. This is the fourth year of this project. Our research is evaluating which tillage approach (chisel plow, vertical tillage, strip till with shank, and strip till with coulters) maximizes early-season soil warming and crop yields, while at the same time, improving soil health on subsurface drained and naturally drained clay and silty loam soils in the northern and southern Red River Valley (where growing degree units are a primary consideration for management selection).

Enhancement of Survey Efforts for Corn Pests in Minnesota (2018)

University/Company: University of Minnesota
Principle Investigator: Bruce Potter

Maintaining corn yield increases in the presence of new and evolving insect and pathogen pests has required sustained improvements in corn genetics, crop management practices and pesticides. Advances in insect-resistant and herbicide-tolerant genetically modified organism (GMO) technologies, combined with high corn values, created an environment where pest management was taken for granted. Insect, disease and weed control was often handled in a "one-size-fits-all" prophylactic manner.

With more effective pest management and difficulties in interpreting survey data under widespread use of new GMO technologies, long-term, public pest survey efforts were largely abandoned during the late 1990s. This greatly diminished survey activity seemed wise initially, but it reduced our ability to detect and understand how risks from key corn pests were shifting.

Currently, corn farmers face several issues that make understanding changes in pest problems increasingly important including, more arthropod pests of corn have populations resistant to insecticides (e.g. corn earworm, corn rootworm, two-spotted spider mite); Bt traits (e.g. western bean cutworm, fall armyworm, corn earworm, western corn rootworm) or crop rotation (e.g. northern corn rootworm).

These biotype shifts create integrated pest management (IPM) challenges with respect to viable hybrid trait and insecticide options for pest management. These challenges include changes in the complexity of existing and new corn pathogens (e.g. bacterial leaf streak, northern leaf blight, Goss's wilt) that require corn farmers and their advisors to understand these risks to react with appropriate management; environmental concerns that may limit the future scope of pesticide tools available; and migratory insects (e.g. true armyworm, black cutworm) and other insects and pathogens that can become more problematic with changes in weather and cropping practices (e.g. tillage, cover crops); and farmers who may react to current low commodity prices by reducing genetic traits (e.g. Bt) or pesticide (e.g. at-plant rootworm) inputs.

From an (IPM) perspective, a reduction in pest management inputs is advisable when it is based on knowledge of a pest population that indicates an economic advantage to do so. Our ability to select corn hybrids with high, stable yields requires understanding near and long-term changes in pest populations.

As new pests and diseases become problems and pest resistance to widely used genetic and pesticide tools increases, understanding risk from pests becomes increasingly important to corn farmers, particularly when farm revenues decrease. This project consists of enhancements to, and the coordination of, ongoing projects for assessing corn pests. It also includes development work for several new research projects. Together, these projects are intended to improve our understanding of spatial and temporal difference in the populations of economically important Minnesota corn insects and diseases. Ultimately, it is hoped that this project will lead to a long-term cooperative effort to predict and quantify changes in losses from corn pests.

Food Grade DDG for Human Consumption - Value Enhancement of a Corn Co-Product (2018)

University/Company: South Dakota State University
Principle Investigator: Padmanaban Krishnan

The purpose of this study is commercial development of Food Grade Distillers Grains. New food grade ethanol plants have come on-line in recent years and are a significant development since there is now an even greater need for new markets and new applications for a co-product of ethanol production. The goal of the research is to use part of the stream in ethanol plants for the production of wholesome dried distillers grains (DDG) that meets the specifications of a food ingredient.

This research proposes to develop a set of specifications to serve as a standard. The research will also determine the minimum inputs to processing DDG while maintaining minimal cost. Minimal treatment inputs administered to DDG streams at the ethanol plant are key to an inexpensive but high-value food grade DDG. Laboratory investigation will lead to optimization of the corn substrate used for fermentation.

Value Added Materials from zzCorn Stover (2018)

University/Company: University of Minnesota
Principle Investigator: Marc A. Hillmyer

Our overall goal in this project is the utilization of abundant and readily available organic chemicals derived from corn stover for the preparation of new polymeric materials through the discovery of novel chemical transformations. Polymerization of reactive monomers to produce materials having versatile properties and applications is the backbone of the polymer and plastics industry. The discovery of unique polymerizable monomers and of new methods for polymerization using corn-derived chemicals will lead to novel materials having unique and useful properties.

Through the efforts in this proposed research project, we aim to expand bio-based opportunities by conversion of the highly functional molecules that can be derived directly from abundant corn-based biomass into materials with high-potential value. Through new efficient transformations, our team will significantly advance the existing knowledge in the area of selective and high-yielding chemical transformations of low-cost and abundant functional molecules into higher-value, polymeric materials.

Corn-Derived Materials: Isoprene/Rubber and Toughened Poly(lactide) (2018)

University/Company: University of Minnesota
Principle Investigator: Marc A. Hillmyer

In the Dauenhauer group, the proposed work aims to evaluate the catalytic conversion of sugar to isoprene using thermochemical solid-acid catalysts. Glucose obtained from corn can be reacted to the intermediate itaconic acid, which is hydrogenated to 3-methyl-tetrahydrofuran (3-MTHF). 3-MTHF then undergoes catalytic dehydra-decyclization to form isoprene product and water. In this work, the reaction to produce isoprene will be evaluated using all-silica solid acid catalysts, with the objective of maximizing yield and process economics for producing isoprene.

Poly(lactide) (PLA) is a commodity plastic produced by polymerizing lactide monomer, which comes from a process of fermenting sugar derived from corn. This material has many desirable and commercially important properties, including stiffness, tractable glass transition and melting temperatures, optical clarity, and thermal processability.

A recent discovery by Bates and coworkers revealed that nanoscale block copolymer micelles could be dispersed in commercial PLA using either solvent casting or melt blending approaches. The resulting nanocomposites exhibited remarkable toughness in tension and Izod impact tests. This project will explore the fundamental thermodynamic principles that govern mixing of block copolymers and PLA, and explore the mechanisms responsible for imparting mechanical toughness.

Impact of Delays and the Cost of Permitting to Minnesota Agriculture (2018)

University/Company: Informa Economics
Principle Investigator: Scott Richman

The purpose of this project is to determine the impact on key parts of Minnesota's agriculture sector from delays in obtaining government permits. To protect the environment, maintain resources, or otherwise comply with laws and regulations, Minnesota requires that industries obtain various permits

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from state government (or the federal government). However, in recent years, some agriculture-related industries have reportedly experienced significant delays in obtaining standard permits that are needed to build, expand or operate facilities.

Specifically, this project will attempt to determine "the cost to Minnesota concerning our permitting environment for facility expansion, current operating permit renewals and construction of new facilities particularly in the ethanol production and livestock production sectors."

Considering that Minnesota is among the top-five states in the production of ethanol and hogs, and that it has a significant number of cattle on feed, delays in obtaining permits could have a material economic impact. Informa's analysis will focus on the ethanol, swine production and cattle feedlot industries, but to the extent that information on other parts of the agriculture sector is gleaned during the research, this will be discussed in Informa's report as well.

Informa's work will be conducted in two phases. In Phase One, the delays that operations in the target industries have been experiencing will be determined. In Phase Two, the impacts to the agriculture sector and the broader economy will be estimated. As described below, each of the phases will consist of several tasks. Note that while the phases and tasks are discussed separately for purposes of this proposal, in reality there will be some overlap as the work is conducted, since some of the research and activities (e.g. interviews) will be relevant to more than one task.

Monoethylene Glycol (MEG) Production from Corn (2018)

University/Company: Iowa Corn Promotion Board
Principle Investigator: Alex Buck

This project is a collaboration in support of a project to develop monoethylene glycol (MEG) from corn starch. The Iowa Corn Promotion Board (Iowa Corn) has developed a novel, patented process over the last four years for the production of MEG from corn using a one-step process to replace MEG made from fossil fuels and the multistep process currently used in the production of bio-MEG from sugarcane-based ethanol. Union Carbide developed the first commercial MEG plant in 1925, and, today, MEG is a global commodity made from a variety of fossil fuels such as natural gas liquids, naphtha, and coal, with minor amounts made from bio-based materials.

MEG is used to make polyethylene terephthalate (PET) in the form of bottles for bottled water and soda, as well as polyester for textiles. MEG is also the antifreeze used in commercial and personal vehicles. Previous researchers have relied on the dehydration of ethanol to make bio-MEG so the resulting ethylene can be utilized in the traditional pathways to MEG as a direct drop-in. This path to bio-MEG is plagued by the need for multiple production steps and purifications, which lead to yield loss and increased production costs.

Iowa Corn uses a single-step reaction, followed by purification to turn corn starch/sugar into MEG. We use catalysts (no enzymes or microbes) to do a retro-aldol reaction, followed by hydrogenation in one step of sequential reactions. We believe this will give us a competitive advantage in the market place by lowering the overall cost of production of MEG from corn to increase adoption of this new use of corn.

Ethanol Reformer for On-Board Octane Control in Spark Ignition Engines (2017)

University/Company: University of Minnesota
Principle Investigator: William Northrop

In this preliminary investigative project, the University of Minnesota team will design and construct a small reactor for partially reforming ethanol and ethanol blends at high thermal efficiency. The design is based on fundamental research that the principle investigator (PI) has done under a National Science Foundation (NSF) grant entitled, “High Equivalence Ratio Partial Oxidation of Liquid Fuels by Reactive Volatilization”.

In the prior research, we have investigated the use of non-premixed short contact time reactor architectures for partially reforming liquid fuels. In the reactor (to be constructed), air is sent through a porous catalytic substrate coated with reforming catalyst. Initially, the air is preheated to allow reactions to begin.

Once initiated, the heating element will no longer be needed to sustain the reforming reactions. Fuel is atomized and sprayed directly onto the opposite side of the hot catalyst. The two react at short contact time and ethanol is partially converted to reformed gas species like hydrogen, methane and carbon monoxide. The gas mixture can then be sent to the intake of a spark-ignition (SI) engine to alter ignition properties of the fuel.

Altering ignition properties is one strategy for enabling advanced low temperature combustion modes in engines. Ethanol is an ideal fuel for reforming, as it decomposes at a lower temperature than gasoline on typical reforming catalysts and has a low sooting tendency in low oxygen environments. The reforming reactor will be bench tested and simulated using computer software in this research project.

Nutritional Improvement of Corn Ethanol Co-Products via Yeast Engineering (2017)

University/Company: University of Minnesota
Principle Investigator: Bo Hu

Co-products generated from corn ethanol bio-refining, for instance, Dried Distiller's Grains with Solubles (DDGS), are very attractive in animal feeds as partial replacement of some more expensive and traditional feeding materials for energy (corn), protein (soybean meal), and phosphorus (mono- or di-calcium phosphate). However, variability in nutrient content and digestibility, especially the lower digestibility of most amino acids compared to corn and soybean meal, has been observed, and extra undigested nutrients are then excreted to the manure, causing environmental concerns.

The project will focus on improving the nutritional value of corn ethanol co-products by increasing the level of several key amino acids, such as lysine, tryptophan and arginine. This will be accomplished by genetic engineering of the yeast Saccharomyces cerevisiae to accumulate a higher content of key amino acids in the cell biomass during the ethanol fermentation, thereby increasing these amino acids in the final co-products. Improving the nutritional amino acid balance of such ethanol co-products would minimize the cost associated with nutrient supplements and decrease the discharge of nitrogen to the environment.

Corn ethanol co-products are serving significant roles in the global feed market, and they have become a more important revenue source for the ethanol industry. The proposed project will improve the utilization of co-products with more nutritionally balanced components and will benefit the animal feed industry and corn growers.

Whole Corn Grain Meal Inclusion in Commercial Shrimp Feeds (2018)

University/Company: RALCO Nutrition
Principle Investigator: Misael Rosales

The world farm production of shrimp in 2014 was 9.02 trillion pounds. The estimated world consumption of feed consumed by shrimp farms was 16 to 20 trillion pounds in 2014. Wheat grain and/or by-products (e.g. wheat middlings) levels typically average around 30 percent of shrimp feeds. Thus, approximately 4.8 to 6 trillion pounds of wheat grain and/or by-products were consumed by commercial shrimp feeds in 2014. The world's shrimp farm production is increasing by over 7 percent per year, with the prediction to reach the size of chicken production in the future.

A major reason why corn grain is not being used in shrimp feeds instead of wheat grain and/or by-products is the contamination level of aflatoxin, caused by Aspergillus flavus, in corn across the world, particularly the sub-tropical and tropical regions. Considering the very small incidence of aflatoxin in Minnesota corn, plus the demonstration that corn could replace wheat grain and/or by-products in feeds with no reduction of shrimp farm production/acre, indicates that a potential new market for Minnesota corn can be established.

Nutrient Management Specialist for Agronomic Cropping Systems (2012)

University/Company: University of Minnesota
Principle Investigator: Carl Rosen

Minnesota Corn partnered with University of Minnesota to hire a nutrient management specialist to provide leadership for programs dealing with environmental issues related to nutrient management of corn cropping systems. Research and education activities for this position continue to emphasize the links between nitrogen management, water quality and economic impacts. This is a greatly-needed position that will help provide continuity and support for nutrient management programs.

Climate Change Impacts on Minnesota Corn Production and Environmental Consequences (2017)

University/Company: University of Minnesota
Principle Investigator: Tim Griffis

With past support from the Minnesota Corn Research and Promotion Council, we have significantly advanced the development of the University of Minnesota Mesocosm Facility (http://biometeorology.umn.edu/). This facility is allowing us to probe how climate and management decisions impact corn productivity and some of the critical environmental side effects of food production.

Twelve of the mesocosms are now fully functional and being used in trials. Updates regarding the mesocosm facility and experimental trials can be obtained at the above website. Despite numerous challenges in building and testing each mesocosm, our research continues to advance this facility. We are poised to conduct more collaborative investigations that explore processes ranging from the microbe to whole plant canopy scales.

Our proposed research will begin to develop an ensemble of plausible climate change simulations that represent the next 50 years, and to assess impacts on corn productivity, as well as examine the impact of timing nitrogen fertilizer applications to match crop demand.

Nitrogen Smart (2018)

University/Company: University of Minnesota
Principle Investigator: Brad Carlson

The Nitrogen Smart program was conceived by leadership at the Minnesota Corn Research and Promotion Council (MCR&PC) and the Minnesota Agricultural Water Resources Center (MAWRC), and developed into a program by University of Minnesota Extension. The program has been a three-way partnership, with MCR&PC providing financial and promotional support, MAWRC providing administrative assistance with registration and attendance tracking, and University of Minnesota Extension providing content, teaching, and evaluation.

The program consists of a three-hour training on how nitrogen behaves in the environment and how this affects nitrogen fertilizer management, as well as environmental concerns. There have been 25 meetings held the past two years, with an attendance of approximately 600. While having no official status, attendees receive “Nitrogen Smart” designation for having attended. Evaluation data from this past year indicates 86 percent of attendees would recommend attendance to another, and 86 percent intend to maintain their “Nitrogen Smart” status.

This well-established program is currently engaged in its third year, with 553 people receiving “certification” over the past two years. A second component of this project is to complete the on-line curriculum development component in 2018.

Advanced Nitrogen Smart (2018)

University/Company: University of Minnesota
Principle Investigator: Brad Carlson

The Nitrogen Smart program has been a success, with documented outcomes showing reductions in unnecessary nitrogen (N) fertilizer applications and increased profits due to changes in application practices. The program offers “certification,” although it has no legal status. This certification is good for three years. The program is now poised to enter its third year in 2018, meaning that 2019 will see the

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first group of attendees needing to recertify. Written evaluations of the program show that approximately 89 percent of attendees state they will maintain their certification status when it expires.

Conversations over the past few years with partners Minnesota Corn Research and Promotion Council (MCR&PC) and the Minnesota Agricultural Water Resources Center (MAWRC), participants, and others poised to give input, have examined how to handle recertification. There are multiple options for this, but one option receiving support is to offer "Advanced Nitrogen Smart." Evaluation data shows that approximately 73 percent of previous attendees say they would be interested in attending an advanced course.

A model that has been successful for Extension in recent years is to offer focused training around a single topic. We believe this is the preferred way to approach Advanced Nitrogen Smart, and propose to develop a number of these trainings over time. After consulting with the group that collaborated on the original version of Nitrogen Smart, the consensus is to develop a session focusing on manure applications first.

Evaluation data shows that approximately 50 percent of attendees are using manure as a fertilizer source on at least some of their land. Manure has been challenging to manage in the context of Nitrogen Best Management Practices due to the complexity of managing livestock production facilities, balancing time management, and the variability of manure itself.

This project will develop Advanced Nitrogen Smart – Manure Management. This will be the first of what is envisioned as several Advanced Nitrogen Smart presentations, and it represents the expansion and evolution of this highly successful program. The program will be delivered during the 2019 winter meeting season and into the future.

Engaging Natural Resources Professionals, Drainage Contractors, and the General Public Regarding Issues Related to Agricultural Drainage and Water Quality (2013)

University/Company: University of Minnesota
Principle Investigator: Brad Carlson

This project involves delivering presentations and/or displays to audiences at conferences and meetings around the state concerning the activities and resources that the University of Minnesota has related to environmental stewardship, specifically, agricultural drainage and fertility management pertaining to water quality.

University of Minnesota Extension Water Quality, Nutrient Management, and Agricultural Drainage Education (2018)

University/Company: University of Minnesota
Principle Investigator: Michael Schmitt

Issues related to water quality have been at the forefront of Minnesota agriculture in the past several years, and it appears the issues will continue for some time. The future of agriculture is tied to our ability to manage water and nutrients in ways that ensure a strong agricultural economy and maintain Minnesota's environmental integrity. Sound research-based education delivered to producers, natural resources professionals and citizens is key.

This project is a continuation of an existing collaboration between University of Minnesota Extension and Minnesota Corn, to bring in-depth education/outreach expertise to research-based issues pertaining to water quality/water management, especially as it relates to plant and soil nutrient management.

The project centers on a dedicated position that will unite existing information and the greater resources of the University of Minnesota and other institutions to provide unbiased, research-based education around nutrient management, water quality and drainage issues. The end goal is a sustained agricultural economy.

Vegetative Cover Crops as a Nitrate Reduction Strategy for Tile Drainage

University/Company: University of Minnesota
Principle Investigator: Jeff Vetsch

Nitrogen (N) is an essential input for profitable corn production. Previous research (Randall and Mulla, 2001, Dinnes et al., 2002) has shown subsurface tile drainage systems deliver nitrate-N to surface waters and thereby degrade water quality. Row crop agriculture in the Midwest is under scrutiny to reduce nitrate (NO3) concentrations and loads in tile drainage. The use of cover crops and applying appropriate rates of N for corn are potential management strategies to reduce NO3 losses in tile drainage water (Dinnes et al., 2002). The species of cover crop, establishment date and termination date could greatly affect their potential to sequester N. Cereal rye is effective at scavenging N when it's established early and not terminated until spring.

Generally, Minnesota farmers who use cover crops either use cereal rye in a no-till system or seed a blend of annuals like oat, annual rye, clover and radish. These annuals are terminated by cold temperatures and/or tillage. The potential of fall/winter terminated covers to scavenge N in a corn-soybean rotation in Minnesota is not well known. The goal of this study is to quantify the effects and interactions of cover crop management and N rate on tile water flow, NO3 - N concentration and loss in tile drainage water, corn and soybean production, N uptake and nitrogen use efficiency (NUE).

Impact of Cover Crop Strategies on Productivity of Corn (2018)

University/Company: University of Minnesota
Principle Investigator: Axel Garcia Y Garcia

The dominant crops in Minnesota are corn and soybean. Combined, they are responsible for more than 80 percent of the $9.25 billion value of the state's field and miscellaneous crops in 2014 (USDA-NASS, 2015).

Corn and soybeans are typically grown in rotation using conventional cropping practices, including high external inputs. The practice is under scrutiny due to issues with soil erosion and nutrient losses, such as nitrogen in the form of nitrate (NO3). Cover crops integrated into current cropping practices have been promoted as an affordable and environmentally friendly option for crop production.

Intuitively, cover crops will use water and nutrients and may negatively influence weed, insect and pathogen populations. But the strategy is expected to result in a more efficient use of resources, while maintaining or improving productivity and enhancing the quality of the environment. The goal of this proposal is to assess the impact of cover crop strategies on the productivity of corn grown under different environments and production practices.

INNOVATION GRANTS

Some of the greatest challenges currently facing Minnesota corn farmers may have solutions that growers have already thought of or have had the insight to try. Innovations like these often can be furthered through "seed" money to test the idea on a limited scale for workability and potential to help other farmers address identical challenges in their operations.

To foster farmer-led innovative solutions to solve a specific challenge, the Minnesota Corn Research & Promotion Council (MCR&PC) and the Minnesota Corn Growers Association (MCGA) allocated funding to aid farmers with an innovative practice that they wanted to test or prove on their farm.

With an anticipated focus by citizens and legislators on nitrate loss and soil conservation efforts in Minnesota agriculture, MCR&PC and MCGA released a request for proposals (RFP) to Minnesota corn farmers. The RFP requested proposals from farmers with interest in testing their ideas related to improved nitrogen management and/or conservation practice through an on-farm project in corn production or more sophisticated replicated trials.

Integrating Swine Manure Application and Strip Tillage into a Single Pass System.

Lee Thompson

Manure application is a challenge for many farmers due to time constraints and adopting new application practices. The goal of this project is to combine the field operations of strip tillage and manure application into a one-pass system, while improving soil health and ensuring a sustainable manure application method. I believe that by banding the manure in the strip, application rates can be reduced, and we can be more efficient with our manure.

I hope to determine if combining the field operations of strip tillage and manure application into a one-pass system will promote soil health, reduce nutrient loss, increase yields, and allow the farmer to complete field operations in a timely fashion, while adopting new farming technologies.

Inter-Seeding Cover Crops While Applying In-Season Nitrogen

Keith Hartmann

Since applying for an Innovation Grant, the statements, "Cover crops won't work here" and "You are planting weeds into your corn" have turned into

questions such as, “Where can I get the seed?” and “What is the best method to plant it?” The change to these kinds of questions from fellow farmers inspires me to replicate my 2016 and 2017 Minnesota Corn Innovation Grant research of inter-seeding cover crops into V6 corn, while applying in-season nitrogen in the same pass across the field.

This project will demonstrate an efficient and effective way to seed a cover crop during a side-dress nitrogen application. I will be applying this practice to 110 acres of corn. Within those 110 acres will be replicated strip trial plots where I will be weighing corn grain yield, performing stalk nitrate tests and soil nitrate tests. These tests are to ensure that the cover crop isn’t negatively affecting the primary corn crop in any way.

I will continue to use pre-emerge and post-emerge herbicides, with residual characteristics to test cover crop tolerance and to demonstrate that weed control won’t be sacrificed to establish these cover crops. Using the same management practices as a typical corn farmer is important to making this a sustainable practice.

Sulfur Application at Nitrogen Side-Dress and Cover Crop Planting

Brian Ryberg

Our goal is to determine which level of overall Sulfur has the best ROI based on yield and which level provides no additional response to yield. We are interested in working with Sulfur, and its effects on Nitrogen uptake. We have seen a definite advantage to using more Sulfur and we are wondering if we could see more benefits in our banded situation with our strip till system.

There is an obvious relationship between Sulfur and Nitrogen on yield. We will be testing different levels of Sulfur (S) or ammonium thio-sulfate (ATS) added into our 32 percent nitrogen solution at side dress time around V-5 to V-6. Our corn acres already have an application of ammonium sulfate (AMS) applied in the strip this fall, so our trial would be in addition to what is applied already. Our side dress applicator is a 36-row machine, with rows spaced at 22 inches (0.56 m).

We will be doing this on a large farm to do some replications. We will make one round, 72 rows, with no added ATS, then add additional ATS for each of several rounds after that, and then repeat the procedure. These “blocks” of different ATS levels will be easily identified on a yield map, and we will also have a weigh wagon to determine yield on these strips at harvest.

Evaluating Optimum Inter-Seeding Dates for Soil Health and Weed Control

Matt Alford

Our farming operation consists of 1,320 acres located in Faribault County seven miles east of Blue Earth, Minnesota. We currently raise corn and soybeans and are looking for the best way to integrate cover crops into this production system. We have been strip-tilling since 2009, and we believe that cover crops can help us achieve our soil health and sustainability goals. The benefits of cover crops are numerous, and we have witnessed many of them first hand.

Establishing cover crops in the northern corn-belt can be a challenge. Inter-seeding cover crops while applying nitrogen is the best way to address this issue. This is considered a novel practice in our area as it consists mostly of heavy tillage. In a marginal farming economy, farmers are looking at maximizing every dollar on their operation and cover crop seed and application are not any different. Combining a side dress application of nitrogen along with cover crop seeding is a very efficient way of reducing trips through the field and, ultimately, leads to more profitability and cover crop adoption.

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This project will give insight into both issues and provide farmers with real field-scale data showing how this practice can be implemented. I will add a Hiniker cover crop seed box to our already existing side dress unit. The unit is a 40-foot 7x7 toolbar consisting of 16 soil warrior "mini" units. The soil warrior units employ a wavy lead coulter and two containment coulters. The liquid nitrogen is applied directly behind the lead coulter and the containment coulters cover it with soil and residue. The cover crops would be applied in front of the toolbar and the containment coulters would essentially "plant" the seeds. This seeding method would achieve optimum seed-to-soil contact, allowing the use of lower seeding rates, which wastes less seed and money.

The theory of this experiment is that early established cover crops can outcompete much of the weed pressure that would arise throughout the growing season. The cover crop mix we will be using is 10 pounds annual ryegrass, 1 pound radish, 1 pound rape, 3 pounds buckwheat and 4 pounds cowpeas per acre. This mix is designed so that it contains a cool season grass, cool season broadleaf, warm season broadleaf, warm season legume, and the corn that will be planted amongst is a warm-season grass. A diverse mix such as this can aid in weed control and add many benefits to a conservation farming system.

The experiment will be conducted on full-length rows in 16 row blocks. A control plot on both sides of the trial will use pre- and post-emerge herbicides and no cover crops. Three of the blocks will be inter-seeded while applying nitrogen. Each block will be seeded at different growth stages of the corn. Corn growth stages will be identified using the leaf collar method.

The first test will be applied at V-3 (treatment #1), the second at V-5 (treatment #2) and the third at V-7 (treatment #3). An additional check plot will be evaluated in which we only apply pre-emerge herbicide and not inter-seed (treatment #4). This will provide a comparison to evaluate the weed control that the cover crops are providing in each treatment. The controls, as well as the weed control check plots will all receive a side-dress application of nitrogen at approximately V-5, or when the rest of the field is applied.

While side-dress nitrogen timing is an additional variable between the treatment plots, controls and weed checks, this small-time difference has been proven to have no statistical difference on yield. All treatments, control plots and weed check plots will be replicated one additional time. One corn hybrid will be planted across the whole area, and this experiment will be in a uniform part of the field to help minimize any variances in soil type or elevation.

Economic and Agronomic Study of Various Variable Rate Nitrogen Programs

Les Anderson

The purpose of this project is to evaluate some of the Variable Rate Nitrogen (VRN) programs against a check to see if they can reduce the amount of N per bushel of corn produced, and to see if there is enough economic return to pay for the program. The field is about 68 acres (27.5 ha) in size, naturally well drained with no tile, and very uniform, consisting of mainly one soil type, with soybeans as the previous crop.

We will compare VRN programs from Winfield, Climate, and Premier Crop/AYS against a check. The strips would be 80-feet (24.4 m) wide, about 1,200-feet (365.8 m) long, with a 40-foot (12.2 m) planter making two passes, planting a single variety. We will only harvest the inner 40 feet (12.2 m) of the 80-foot (24.2 m) pass for yield measurement. To aid in accuracy, I will identify and assign the plots in the monitor at time of planting. Headlands and borders will not be used in the study. Urea would be the source of N. The entire field would be spread prior to planting with 80 pounds (89.7 kg ha-1) of N plus sulfur. The check would be 70 pounds (78.5 kg ha-1) of N plus sulfur side dressed, with the other three treatments being planted in succession, resulting in eight replications across the field. Agrotain would be added if conditions warrant.

Todd Anderson and Dan Jilk from Ag Partners and I will set up the plot, and they would load the prescriptions and apply the fertilizer. I will combine the plot, using a calibrated Ag Leader monitor to record the data. We will analyze the data at the plot level and at the field level. We will compile the data and provide the results looking at pounds of N per bushel and cost, both on a per-acre basis and bushel basis, including the cost of the VRN program.

In-Season Potassium and Nitrogen Application Based on Crop Demand Curve, Soil and Tissue Sampling

Kevin Poppel and Kate Stenzel

As an essential nutrient, potassium (K) plays a critical role in corn plant development and chemical processes. As a result of the number of roles it plays in the plant, potassium uptake and utilization often interacts with the availability and uptake of other nutrients. Potassium specifically affects the uptake of nitrate nitrogen into the plant.

According to research done by the International Plant Nutrition Institute, higher yields and nitrogen utilization is improved with adequate potassium levels. There is also greater yield response to nitrogen applications when K is sufficient, as well as improved crop response to K when nitrogen is sufficient. This interaction is also observed over years of tissue sampling through the entire Central Farm Service territory. That work showed a significant number of samples showing deficient or responsive nutrient concentrations within the plant of both potassium and nitrogen. To maximize yield potential, a critical balance between the two nutrients must be achieved.

An improvement in nitrogen use efficiency has been observed by making split nitrogen applications that closely follow the nitrogen demand curve for corn. The goal for the improvement is also to maintain maximum yield potential. Since potassium and nitrogen are essential nutrients to the corn plant and yield potential, and so closely correlated, an improvement in potassium efficiency would likely be observed if potassium were applied more closely to match the nutrient demand curve.

By identifying a critical balance between these nutrients, the goal is to maximize nutrient efficiency without sacrificing yield. Based on previous nutrient research theories, a yield advantage is possible if the correct ratio is achieved.

Eliminating Soil Erosion Using a Three Crop Rotation and Extensive Cover Crops

Brock Olson

The objective of this project is to develop a crop rotation that significantly reduces nitrate loss and soil erosion, as compared to the traditional corn-soybean rotation, while maintaining profitability in Southeastern Minnesota.

A proven method to decrease soil erosion and nitrate loss is through the use of cover crops. Cover crop use in northern Midwest states is more difficult due to the shorter season. The cover crop that has proven itself fairly reliable in this cold climate is winter rye. In recent years, some have planted winter rye following corn harvest, then planted soybeans the next spring without negative yield effects. Winter rye will reduce soil erosion, reduce nitrate loss, and improve soil structure and health.

Unfortunately, winter rye before corn planting hasn’t had good results, even when terminated 10 days before corn planting. Corn crops are often well behind visually and can have measurable yield reductions. One possible solution to this is to use cover crops that winter kill. The residue from the cover crop will reduce erosion and nitrate loss, but not negatively impact the subsequent corn crop. Adding a third crop to the corn-soybean rotation can allow for more cover crop benefits by allowing additional cover crop growth before winter kill, without negatively affecting corn yields. This project will investigate the possibility and profitability of this third crop in the rotation.

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Yield Costs or Benefits Associated with Different Conventional and Vertical Tillage Practices

Kent Luthi

Proper tillage seems to be a never-ending struggle for farmers across America. Fred Below with the University of Illinois, states that tillage is only number five of the seven wonders of corn production. However, improper tillage can be detrimental to corn growth and yield. To address the costs of improper tillage, we would like to put a few different tillage practices to the test in our own backyard. This will create yield data for area growers to compare when struggling to decide what is right for their operation and to understand the cost associated with malfunctioning tillage tools.

In the fall of 2017, we put in tillage plots across three different farms with three different tillage scenarios: 1) 7-inch standard points, 2) 14-inch 360 Yield Center Bullet points, and 3) a control where we ran no shanks down with only the front disks doing slight mixing (vertical tillage will be used in future years). We plan to determine any difference in soil fracturing and residue incorporation between the three of them before and after winter freeze. We will include the economic cost of tillage skips or malfunctioning shanks due to sheared bolts for each tillage treatment.

Jodi DeJong Hughes from University of Minnesota Extension (Willmar office) and Dorian Gatchell with Minnesota Ag Services will be helping us with proper plot protocol and data collection. They will also assist with tools, such as a soil penetrometer for testing density. We also will work closely with Precision Ag 360 to use tools such as 360 SOILSCAN™ and Climate FieldView™ to track nitrogen availability in each test strip and data collection point.

We hope by replicating this project over multiple areas and multiple years, we can see what difference there may be robbing yields or not, and whether or not deep conventional tillage is always beneficial in different crop rotations.

Real Time Liquid Manure Testing and Nutrient Management

AJ Krusemark

This proposal is intended to test the nutrient analysis of hog manure to adjust application rate on a load-by-load basis, with a goal of applying the manure using a variable-rate prescription.

Building on the information learned through nitrogen management trials in 2017, this project will focus on improving the precision of application rates of injected liquid hog manure to minimize risk of nitrogen losses. Application rates will be targeted to achieve required phosphorus levels, with remaining nitrogen requirements met through side dress or other in-season application methods. Nitrogen modeling programs will be used to prescribe in-season applications with residual nitrate tests conducted to ensure over-application has not taken place.

Nutrient analysis testing will be conducted in one-foot increments throughout the profile of the pit. Additionally, on one pit, each load will be analyzed. Analysis will be conducted on-farm and repeated in a laboratory for each sample to ensure accuracy. This data will be compiled and analyzed in the first two growing seasons to be used to develop variable-rate application capability for year three.

Comparing Economic Benefit of Variable Rate Nitrogen Systems

Sam Peterson

Split application of nitrogen has gained acceptance by growers on more corn acres as a way to potentially increase nitrogen efficiency, crop yields and net profit, as well as decrease nitrogen loss. This typically means applying a portion of nitrogen pre-plant, followed by a seasonal application (top-dress) at the V4 to V7 growth stage.

Recently, a number of variable rate nitrogen (VRN) systems have been developed to further refine the rate of nitrogen applied during top-dress. The rate of top-dress nitrogen depends on a number of factors: yield history, soil type, environmental conditions prior to top-dress, satellite imagery, and soil nitrate test levels. This proposal compares replicated farm scale strip trials of three VRN systems (Encirca®, NitrateNow, R7®) to a planned flat rate (check strip) of top-dress nitrogen on a 335-acre (135.6 ha) field of corn following corn. The trial is trying to answer the following questions: "Which VRN system creates the best economic bottom line when factoring in nitrogen rate and corn yield?" and, "Is there an economic return to the added cost (typically $8-10/acre ($19.8-24.7/ha)) of the VRN systems versus a uniform rate of top-dress nitrogen?"

Advisor Brad Carlson with the University of Minnesota Extension will oversee the strip trial design, and receive and merge nitrogen records from the four treatments into one prescription for topdressing. He will also evaluate yield data and complete a yield and economic analysis.

Drip Irrigation and Nitrogen Management

Brian Velde

The demonstration site has been in a corn-soybean rotation with conventional tillage. The field is well drained and has been grid-sampled for fertility levels. The field has 13 years of yield data, and Real Time Kinematic (RTK) is used for planting consistency. The demonstration site is currently permitted for 58 acres (23.5 ha) of irrigation or 9.6 million gallons (37,097 m3) of water per year to be pumped from the Yellow Medicine River with the Minnesota Department of Natural Resources (MN DNR) permit# 2016-0797.

A drip irrigation system has been designed by Maxwell Irrigation. The system has been installed by NutraDrip Irrigation Systems. The drip irrigation system consists of six different zones, approximately 9.5 acres (3.8 ha). The zones have the ability to apply different rates of water and nitrogen within those zones.

Within the zones, drip tape was installed every five feet (1.5 m) at 16 inches (0.4 m) deep using RTK. This RTK spacing will allow every corn row to have an irrigation/fertigation application done within 15 inches (0.38 m) of the corn roots. The site will have a weather station that will track wind, temp, rain, humidity, solar radiation and GDU's. Two soil probes will be installed to measure soil moisture in different soil types.

The (TO) check will consist of three strategically placed 60-foot (18.3 m) wide nonirrigated blocks with 100 percent pre-plant nitrogen strips running the length of the trial. Treatment 1 (Tl) will consist of six 9.5-acre (3.8 ha) zone blocks that will have subsurface irrigation and nitrogen application based on in-season crop needs. There will be a statistically

quantifiable randomized treatment design with the treatments. In-season tissue samples will be collected from VS to tassel for nutrient analysis and estimates of photosynthesis/ chlorophyll will done by Centrol Crop Consulting using a chlorophyll Soil Plant Analysis Development (SPAD) meter.

Yields will be measured using a yield monitor. We will use paired comparison to analyze data. Data that is not normally distributed, we will use non-parametric analysis. Within the replicated strips, we will use sampling points in the different soil types.

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