GRANT CODE: New

TITLE: Nitrogen stabilizers to improve nitrogen fertilizer efficiency in winter wheat in high rainfall zones of Idaho

PERSONNEL: Dr. Kurtis Schroeder, Associate Professor of Cropping Systems Agronomy

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JUSTIFICATION: Nitrogen stabilizers are currently used by some growers in the region. Others have tried them in the past and opted to use the money that would have been spent on stabilizers to purchase more nitrogen fertilizer for topdressing in the spring. In a previous study conducted by the north Idaho cropping systems program, a series of nitrogen rates was examined in combination with several varieties of soft white winter wheat (Senefsky, 2017). While insight was gained on differential variety performance, there were substantial differences in response to nitrogen between locations. At the Cavendish location in both years of the study, but particularly in the second growing season (2017), there was little response to increasing nitrogen rates. It is suspected that there was significantly more leaching of nitrate at this location during the winter months, resulting in reduced yields. These higher precipitation areas are more vulnerable to leaching, but also years with very wet springs also can result in greater leaching of fall applied nitrogen. There has been little to no research related to using nitrogen stabilizers in winter wheat production in northern Idaho and data on the performance and economic feasibility of these products would be useful to growers.

More efficient use of applied nitrogen and improved stewardship could help improve the profitability and sustainability of Idaho farms. Soil acidification in northern Idaho as a result of long-term use of ammonium-based nitrogen fertilizers is well documented. While efforts are underway to identify tolerant crops and wheat varieties as well as devising cost effective liming strategies, other activities that limit nitrification could be beneficial to the viability of this cropping system. Nitrogen stabilizers might be an additional tool to help prevent future acidification. In addition to improving crop yield, stabilizers may improve the efficiency of nitrogen application, resulting in lower nitrogen requirements in the fall or the need to topdress in the spring. Lower total application rates would slow future acidification.

HYPOTHESIS AND OBJECTIVES: The hypotheses are that application of nitrogen stabilizers will decrease the quantity of nitrogen lost to leaching during the winter months and improve nitrogen application efficiency. Furthermore, use of a nitrogen stabilizer will prove to be more cost effective than applying higher rates of nitrogen.

Specific objectives are to:

1) Monitor the fate of fall applied nitrogen with and without nitrogen stabilizers through soil testing to determine to effectiveness of a nitrogen stabilizer to prevent leaching.
2) Evaluate the crop response to using nitrogen stabilizers.
3) Monitor the population of nitrifying bacteria (*Nitrosomonas* spp.) after application of nitrogen stabilizers using quantitative PCR.
4) Determine the cost effectiveness of applying nitrogen stabilizers with fall applied nitrogen versus using higher rates of nitrogen in the fall or topdress application of nitrogen in the spring.

PROCEDURES:

1. *Field studies with nitrogen stabilizers in winter wheat.* In the fall of 2019, trials were established in Cavendish, ID and Cottonwood, ID. At each location, there are two trials, one with a soft white winter wheat (LCS Hulk) and one with a hard red winter wheat (LCS Jet). In each study five nitrogen rates are being examined (0, 50, 100, 150 and 200 lb/A), each with and without Instinct® II (nitrapyrin, Corteva Agriscience) nitrogen stabilizer. Each study is organized as a randomized, complete block design with four replications. Each individual plot measures 8' wide by 100' long and was planted using a custom AgPro direct seed drill equipped with Bourgault paired-row openers on 12' spacings. The drill is capable of banding liquid fertilizer below and between the seed rows. The source of fertilizer used in this study is urea ammonium nitrate (UAN) and all nitrogen fertility was applied at planting.

   Soil sampling will be conducted at three time points during the growing season to track the movement and form of fertilizer. These will include in the fall once the soil is near freezing (late November), late winter when the soil temperature increases above freezing, and immediately after harvest. The November sampling will be to 1 ft while the late winter and fall samples will be to 4 or 5 feet at 1 ft increments. Soils will be analyzed for ammonium and nitrate by extracting with 2 M KCl using a 1:10 soil to solution ratio soon after collecting samples from the field. Extracts will be stored at -20°C until analyzed for ammonium and nitrate on a Hach Lachat FIA (flow injection analysis, Hach Corp., Loveland, CO) system (Mulvaney, 1996).

   At the late November and late winter samplings, an additional soil test will be obtained to measure biological activity, specifically nitrifying bacterial populations. DNA will be extracted from soil samples using the DNeasy PowerLyzer PowerSoil DNA extraction kit (Qiagen). *Nitrosomonas* spp. will be quantified using specific primers to target the *amoA* gene in conjunction with SYBR Green for qPCR detection (Fisk et al., 2015). All qPCR assays will be run on a Roche Lightcycler LC96 (Roche Molecular Systems, Inc., Pleasanton, CA).

   Agronomic measurements will include fall and spring plant density, spring vigor, number of reproductive tillers and mature plant height. Plots will be harvested using Wintersteiger plot combine to obtain grain yield, test weight and protein.

2. *Economic evaluation of nitrogen stabilizer.* The value of using Instinct will be determined by examining the net gain or loss in yield with each nitrogen rate, taking into account the cost of Instinct. Preliminary estimates will be generated following the first year of the study, with a more detailed multiyear and multilocation analysis in 2021. In addition to the direct impact on yield, an estimate of cost savings by potential decreases in nitrogen leaching will be estimated. An alternative to stabilizers that has been suggested by some growers is the use of additional topdress applications of nitrogen in the fall versus spending money on a stabilizer. This will be considered when determining the economic feasibility of these treatments.

DURATION: This project is anticipated to take 2 years but may be continued for a third year depending on the outcome of the data.

COOPERATON/COLLABORATION: Research plots will be conducted in cooperation with local growers in Cavendish and Cottonwood. Dr. Haiying Tao, Nutrient Management Specialist at Washington State University, will provide guidance and expertise on soil sampling as well as measurement of ammonium and nitrate. Dr. Kate Painter will advise on the economic analysis of

Instinct applications. An MSc student, Ms. Sarah Seubert, will be responsible for this project as part of the requirements for her degree. She is receiving an assistantship from Limagrain Cereal Seeds.

ANTICIPATED BENEFITS, EXPECTED OUTCOMES AND IMPACTS, AND TRANSFER OF INFORMATION:

The work is expected to provide evidence of the utility of using nitrogen stabilizers in winter wheat production in northern Idaho in addition to the economic feasibility of using such products. The work should also contribute to the knowledge concerning how nitrapyrin interacts with *Nitrosomonas* spp. and its influence on populations of this organism. There should be reduced leaching and increased availability of nitrogen to the crop in the spring when Instinct is added to the fertilizer. This data should support the use of nitrogen stabilizer products in areas that are prone to leaching during the winter months. The results of this study will be shared at field days and winter cereal schools. Results will also be shared in the Idaho Grain magazine and published in a journal article.

LITERATURE REVIEW: Timing of nitrogen fertilizer application can be challenging. By applying in the fall, there is an increased risk of nitrogen loss to leaching, runoff and volatilization. Wet field conditions may not allow for late winter application and high rates of nitrogen applied in the spring may not be available to the plant. It is crucial that sufficient supplies of nitrogen are available as wheat breaks dormancy in late winter and it will begin to rapidly assimilate nitrogen as it begins to grow (Franzen, 2017). An alternative is to use nitrogen stabilizers that can temporarily prevent the conversion of applied nitrogen to forms that are prone to loss. As much as 30 to 70% of applied nitrogen can be lost and is dependent on factors such as weather, field management and nitrogen management (Tao and Rogers, 2019).

While Instinct has been shown to reduce nitrogen loss, in many previous studies there was not a clear yield benefit (Ferguson et al., 2008; Ferguson et al., 2009; Fernandez, 2010). However, all of these studies were conducted in corn fields in the upper Midwest in cropping systems very different from the Pacific Northwest. In addition, the primary goal would be to limit nitrogen loss and thereby lower rates of nitrogen fertilizer might provide similar yields to higher rates of fertilizer in which stabilizers were not used. While most of the research has been conducted in corn, a study in Missouri evaluated the effectiveness of Instinct in winter wheat production. There was no noticeable change in the quantity of ammonium and nitrate with Instinct and there was no yield response; however, all the nitrogen fertilizer application and Instinct applications were made in the spring after wheat broke dormancy (Habibullah et al., 2018). There has been little to no research published on fall applied nitrogen banded below the seed.

The conversion of ammonium forms of nitrogen to nitrate is facilitated by two different groups of bacteria. *Nitrosmonas* spp. initiate the conversion to nitrite and *Nitrobacter* spp. convert nitrite to nitrate which is then readily available to the plant. These stepwise conversion events occur in aerobic soil conditions when the soil temperature is above 0°C. Nitrification inhibitors such as Instinct (nitrapyrin) aim to prevent the first step of this process (Franzen, 2017). Nitrapyrin interacts with ammonia monooxygenase (AMO), an enzyme produced by bacteria that oxidize ammonia (Vannelli and Hooper, 1992). This enzyme is an important mechanism by which these bacteria obtain energy and the few studies that have examined the impact of nitrapyrin on *Nitrosomonas* spp. populations are contradictory (Fisk et al., 2015).

LITERATURE CITED:

Fisk, L.M., Maccarone, L.D., Barton, L., and Murphy, D.V. 2015. Nitrapyrin decreased nitrification of nitrogen released from soil organic matter but not *amoA* gene abundance at high soil temperature. Soil Biology & Biochemistry 88:214-223.

Ferguson, R.B., Slater, G.P., and Krull, D.H. 2008. Evaluation of Dow GF-2017 with urea-ammonium nitrate solution for irrigated corn. University of Nebraska Report.

Ferguson, R.B., Slater, G., and Krull, D. 2009. Encapsulated nitrapyrin study, 2019. University of Nebraska Report.

Fernandez, F. 2010. Report on the use of nitrification and urease inhibitors on corn in Illinois. University of Illinois Report.

Franzen, D.W. 2017. Nitrogen extenders and additives for field crops. NCERA-103 Committee SF-1581. North Dakota State University Extension Service.

Habibullah, H., Nelson, K.A., and Motavalli, P.P. 2018. Management of nitrapyrin and pronitridine nitrification inhibitors with urea ammonium nitrate for winter wheat production. Agronomy 8, 204.

Mulvaney, R.L. 1996. Nitrogen – inorganic forms. In: *Methods of Soil Analysis, Part 3*. Eds. Sparks et al. SSSA, Madison, WI. Pp. 1123-1184.

Senefsky, C.W. 2017. Exploring cultivar response of soft white winter wheat to nitrogen and seeding rates, and on farm testing of variable rate seeding. Master's thesis, University of Idaho, Moscow, Idaho. Pp. 131.

Tao, H., and Rogers, C.W. 2019. Nitrogen inhibitors: how do they work to reduce N losses? Washington State University Extension, FS333E.

Vannelli, T., and Hooper, A.B. 1992. Oxidation of nitrapyrin to 6-chloropinolinic acid by the ammonia-oxidizing bacterium *Nitrosomonas europaea*. Applied and Environmental Microbiology 58:2321-2325.

FY2021

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: (insert name)

If applicable,	**Allocated by**	**Idaho Wheat Commission**	**during FY 2019**	**$**	-
If applicable,	**Allocated by**	**Idaho Wheat Commission**	**during FY 2020**	**$**	-

REQUESTED FY2021 SUPPORT:

Budget Categories	(10) Salaries (*staff, post-docs, etc.*)	(12) Temp Help	(11) Fringe	(20) Travel	(30) OE	(70) Graduate Tuition/ Fees	TOTALS
Idaho Wheat Commission	$ -	$ -	$ -	$ 1,000	$ 16,020	$ -	$ 17,020
TOTAL BUDGET REQUEST FOR FY 2021:							$ 17,020

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	*(Insert PI Name)*	*(Insert CO-PI Name)*	*(Insert CO-PI Name)*	*(Insert CO-PI Name)*
(10) Salaries	$ -	$ -	$ -	$ -
(12) Temp Help	$ -	$ -	$ -	$ -
(11) Fringe Benefits	$ -	$ -	$ -	$ -
(20) Travel	$ -	$ -	$ -	$ -
(30) Other Expenses	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -
			Total Sub-budgets	$ -

Brief Explanatory Comments: (see FY2021 RFP for guidance)

Travel funding for managing plots and data collection. Operating expenses will cover the cost of nitrate and ammonium analysis of 1,920 soil samples at $7 per sample and 96 Nitrosomonas samples at $7.50 per sample.

Fall 2019 Version