Proposal # 2 – Ron Wiederholt - $10,573 (year one request, year two request is $10,573)

Canola Seed and Oil Yield Response to 1st and 2nd Year Beef Manure Nitrogen and Sulfur Mineralization

Introduction: Input costs constitute the majority of expense to produce a canola crop. To enhance and optimize profit from canola production, producers are increasingly focusing on ways to better manage nitrogen (N) and sulfur (S) canola inputs. The N:S ratio of beef feedlot manure is very close to the 7:1 ratio required for canola production. With the high price of commercial fertilizers, livestock manure is becoming more attractive as a low cost fertility source for crop production. It is known that manure releases nutrients slowly for crop uptake. However, there are significant gaps in the literature to show conclusively how manure behaves as a crop nutrient source for minor oilseed crops and many other short-season annuals. There is a need for studies that identify the timing and amount of N and S released from manure for uptake by minor oilseed crops. Therefore, the objectives of the research project outlined in this proposal focus on understanding the multi-year behavior of manure nutrient release and the impact on canola seed and oil production. With a better understanding of the impact of manure on canola production, producers may be able to significantly decrease their fertility input costs, increase profits, and make canola production more attractive.

Canola is known to be a high user of S. Sulfur fertilization is a standard practice (expense) for canola producers. Research has shown that livestock manure is comparable to commercial fertilizer as a fertility source for crop production[1]. In addition to supplying N and S, manure is also a source of phosphorous, potassium, and organic matter. Unlike most commercial fertilizer, the nutrients in manure are not immediately available to a growing crop but need to be mineralized or released through bacterial and fungal action in the soil. Because of this slow release, manure nutrients are available for crop uptake years after a manure application[2].

There has been some exploratory work done in ND to look at manure nutrient mineralization. A study was conducted by the PI of this proposal to look at corn response to manure at the Carrington Research Extension Center (CREC) in 2008. This study looked at N and S soil levels in the soil. Table 1 shows soil sulfur levels over the corn growing season using Plant Root Simulator (PRS™) Probes. These probes tracked the amount of nutrients released into the soil every two weeks over the growing season using anion and cation adsorbing membranes. After they are inserted into the soil, PRS probes are removed at specific intervals for analysis to determine the amount of a specific nutrient released during that period. According to Table 1, the plots that received the highest rate of manure, consistently had higher levels of sulfur than those treated with urea N fertilizer and no supplemental S. This data shows that manure does have sulfur supplying power greater than background soil levels.

Contrasting trends in nitrogen availability were also observed in this study when comparing manure and urea as fertilizer sources when corn roots were excluded from the soil sampling area. In Figure 1, total N increased over the season for the manure treated plots and a decreased for the commercial N treated plots. This supports the theory of slow release of N and other nutrients from manure over the growing season. The PRS probes measured significantly higher levels of available N over the growing season following commercial N fertilizer compared to manure. However, this did not impact yield since there was no difference in grain yield between the commercial N and the manure treated plots (data not shown).

Manure use for canola production can also impact seed oil yield and quality. A study just completed in Michigan has shown that manure applied to canola can increase the amount and quality of canola oil production vs. urea and S fertilizer[3]. This research showed that dairy and hog manure applied to canola has a slight impact on yield increases but had a significant increase on oil production. No hypothesis was given by the authors to explain these results. Another study conducted in Saskatchewan at several locations showed mixed results when using manure as a fertility source for canola[4]. At one location manured plots performed as well as commercially fertilized plots and at a second location, the seed yield was lower on manured plots. The authors theorize that part of the yield decreases from manure may be due to the fact that N mineralization from manure did not happen fast enough for short season annual crops. These studies demonstrate that manure has been used as a viable source of N and S. Questions still remain on the timing of nutrient release and when is the best time to apply manure to crop fields. Since manure is a slow release fertility source, does a spring application of manure supply nutrients quickly enough for all crops? In the Michigan canola and manure study, maybe the slow release of nutrients hindered a yield response.

In response to the question of manure application timing and N availability, a study was initiated by the PI of this proposal at the CREC in 2008 and repeated in 2009 to determine the impact of fall vs. spring applied beef manure on hard red spring wheat yield and grain protein. Treatments included; fall applied manure, spring applied manure, spring applied urea and a check with no N. According to Figure 2, neither spring nor fall applied manure yielded as much as spring applied urea. However, the manure treatments did yield significantly more than the check treatment. The impact of slow release nutrient availability from manure was even more pronounced on wheat kernel protein. The results in Figure 3 show that kernel protein was significantly lower and no different than the plots with no fertilizer regardless of manure application timing. T

Another preliminary study conducted at the CREC by the PI of this proposal suggests that the year after a manure application may be the best year to plant a short season annual crop. The study was conducted in 2006 where spring wheat was planted into plots that had manure at two levels and commercial N applied to corn the year before. No additional fertilizer was applied during the wheat year. According to Figure 4, nutrient carryover from manure applied a year before the wheat at the recommended rate and 1.5 times the recommended rate showed higher yields than the carryover from commercial N fertilizer applied at the same rates.

These results are in contrast with data shown in Figure 2 and 3, lending support to the idea that short season crops with high nutrient demand early in the growing season may benefit from preceding year applications of manure that allow for increased mineralization. Unfortunately, no in-season soil fertility testing was conducted during the 2006 study.

Canola is a short season crop similar to spring wheat with early season nutrient demands. The data presented here suggests the possibility that short season crops with early season nutrient demands may benefit more from manure applied in the preceding crop year. No research has been conducted under Northern Plains growing conditions to determine the best way to manage manure as an N and S source for canola production with a focus on the behavior of manure as a multi-year nutrient source. There has always been a history of beef production and availability of manure in ND. The amount of manure available for crop producers is forecasted to increase because of the proposed establishment of a beef slaughter facility in ND.

Objectives:

Objective 1 of this proposal is to test canola performance, seed and oil yield under first year manure application conditions.

Objective 2 of this proposal is to test canola performance, seed and oil yield under second or previous year manure application conditions.

Objective 3 is to evaluate N and S soil fertility levels in year 1 of a commercial fertilizer and manure application.

Objective 4 is to evaluate N and S carryover soil fertility levels the year following a commercial fertilizer and manure application.

Rationale and Significance: The rationale for conducting this research is clearly supported by the previous work done at the CREC to investigate the behavior of manure as a crop fertility source. The data outlined in this proposal clearly suggest that a multi-year study investigating manure release over a two year period is needed to better understand the behavior of manure nutrients in the soil and how that behavior can be managed in crop rotations.

The significance of this work is to develop management practices that can increase profits and enhance the attractiveness of growing canola. There is competition for acres on each producer’s farm and the results of this study will show how manure can be used to give canola a competitive advantage over other crops. Given the N and S levels in manure and the need for those nutrients by canola, manure is a natural fit as a competitive fertility source in canola production. It is important to get a better understanding of how to use manure in a canola production system—what is the best application timing and the amount of N and S released from manure.

Approach: To address the problem of managing manure nutrient availability for canola production, a two year field experiment will be established to compare four fertility treatments in two crop rotation sequences. The study is designed to be a two year project in order to track the second year mineralization of the manure nutrients.

Methods and Sequence: The experimental design will be a randomized split plot design with three replication and 15 ft x 30 ft plots. Crop rotation (wheat-canola, canola-wheat) will be the main plot. Fertility treatment will be the sub plot (no fertilizer, commercial N and S at 1X recommended rate, Manure at 1X, and Manure at 1.5X the recommended rate). Fertility treatments will only be applied in year one. The 1X, or recommended application rate, will be determined through soil testing and analysis of the manure products and will reflect the total nutrient needs of the rotation. The manure 1X rates will be calculated at a 50% N mineralization rate. Fresh beef feedlot manure will be used for the manure treatments and urea and ammonium sulfate for the commercial fertilizer treatment. The fertility treatments will be incorporated immediately after applications. All N rates will be applied consistent with the NDSU crop fertility guidelines.

Soil N and S fertility levels in each plot will be quantified throughout both growing seasons using PRS™ probes. Since manure N mineralization is a naturally mediated process in the soil, monitoring of the nutrient release over the growing season is needed to understand the mineralization process. PRS™ probes have been researched in Canada (http://www.westernag.ca/innov/ag_main.php) and have been shown as useful tools to monitor availability of nutrients in soils whether from commercial fertilizer or manure. A PRS™ probe is a stake with an attached membrane that collects ions in the soil. The membrane can be analyzed throughout the growing season to determine the bioavailability of nutrients at any point in the growing season. PRS™ probes inserted into the soil are more appropriate to monitor manure N mineralization than standard soil testing since they capture nutrient ion release over time during the whole growing season rather than one point in time.

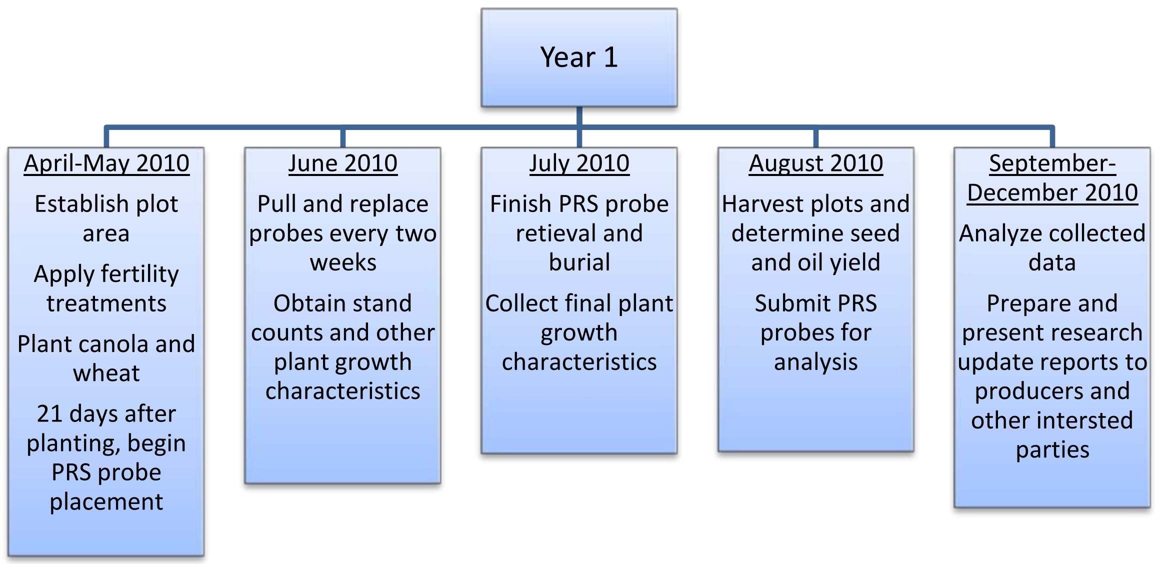
According to procedures by Jowkin and Schoenau[5], three pairs of PRS™-probes (i.e., three cation- and three anion-exchange probes) will be spread throughout each experimental unit and then combined for analysis. This set of probes will track the nutrient release in the soil with root interference by the crop. Another three pairs will be spread throughout each experimental unit in a root exclusion tube to measure nutrient supply without root interference. The use of multiple pairs of probes per plot will account for soil heterogeneity within each replicate. The root exclusion tubes consist of an 8" x 2' tube inserted into the soil. The use of root exclusion tubes will help determine net mineralization versus plant uptake. The plot areas and root exclusion tubes will be undisturbed over the two year period except to establish the second year crop.

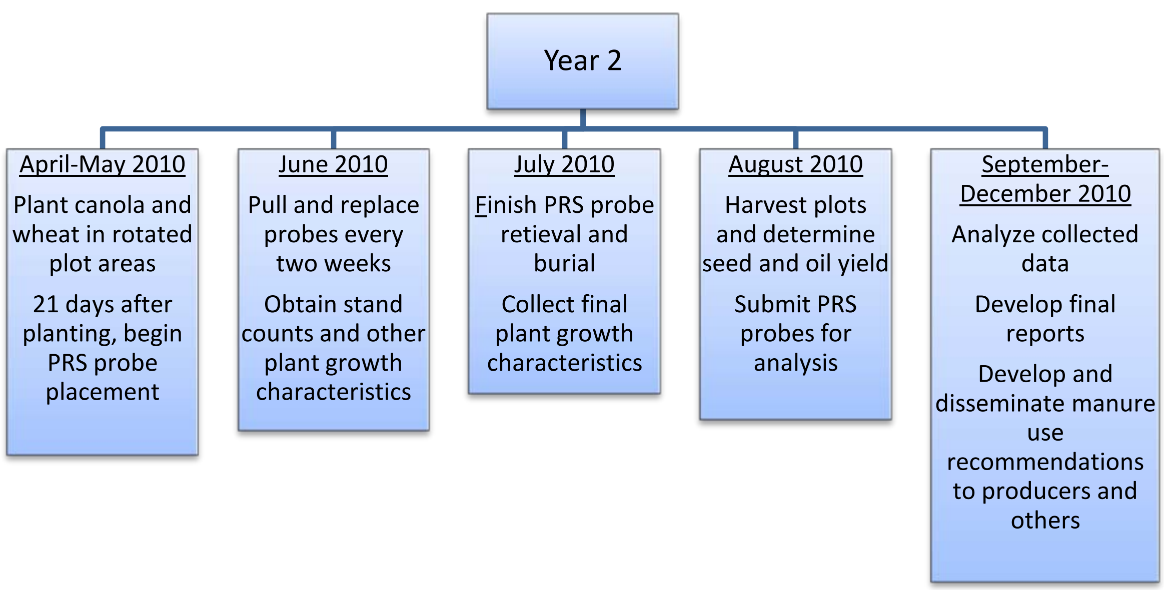
A cumulative measure of nutrient supply throughout the growing season will be measured by removing buried PRS™ probes after 14 days and then re-inserting fresh PRS™ probes in the same soil slot. The probes are buried vertically to a depth covering a span starting at 2 inches below the soil surface and continuing to 5 inches below the soil surface. The first probe burial will take place 21 days after planting and the last set of probes will be pulled at the end of flowering. The pulled probes will be analyzed for nitrate, ammonia and sulfur levels. This allows for the assessment of temporal changes in nutrient supply due to changing environmental conditions. Graphing cumulative nutrient supply rates from repeated burials will be used to assess changes in nutrient supply in situ over time. Weed control in the plot area will be accomplished through NDSU recommended herbicide applications. The canola and wheat crops will be planted at recommended seeding rates.

Other data to be collected includes stand counts, days to beginning and end flowering, physiological maturity, lodging, and grain and oil yield and quality. At the conclusion of the study, grain and oil yield and N and S cation and anion soil levels will be statistically analyzed and compared among the treatments to determine any significant response.

Expected Outcomes and Uses for Results: The expected outcome of this project is a set of recommendations that canola producers can adopt to use manure as an N and S source for canola production without sacrificing seed or oil yield. The results of this study can also be used to delineate future manure nutrient use research projects.

Timeline:





Outreach/Extension Activities: The results of this research will be made available to producers and the general public in a multitude of methods. Reports will be published in the CREC Annual Report, CREC Report of Progress, placed on the NDSU nutrient management website (http://www.ndsu.edu/nm) and any other pertinent publication method. The outcomes will be used by the area extension nutrient management specialists at the CREC and the Dickinson Research Extension Center and incorporated into their educational programs that are presented statewide. The PI of this proposal is a member of the national eXtension livestock waste management community of practice (COP) and will incorporate results of this research project into frequently asked questions and articles published on the eXtension COP website.

Table 1. Soil sulfur levels from June to September following a spring application of manure and urea fertilizer applied at the recommended and 1.5 times the recommended rate as determined by plant root simulator (PRS^TM) probes under plant root exclusion conditions

	Fertility Treatment					
	1x Urea		1x Manure		1.5x Manure	
Sampling Period			S (µg/10cm2)			
5/27-6/10	71.93	c*	213.27	b	359.73	a
6/10-24	84.40	b	209.40	ab	305.80	a
6/24-7/8	142.00	b	151.33	b	222.33	a
7/8-22	75.47	b	113.33	ab	127.60	ab
7/22-8/5	85.73	b	88.00	ab	133.07	a
8/5-19	55.07	b	97.93	ab	123.67	a
8/19-9/2	62.33	b	73.80	ab	110.73	a

*Means followed by the same letter are not signify different across fertility treatments within each sampling period (p=0.05)

Figure 1. **Soil nitrogen over time after spring urea (N) and manure (M) treatments applied at the recommended and 1.5 times the recommended rate under root exclusion conditions**

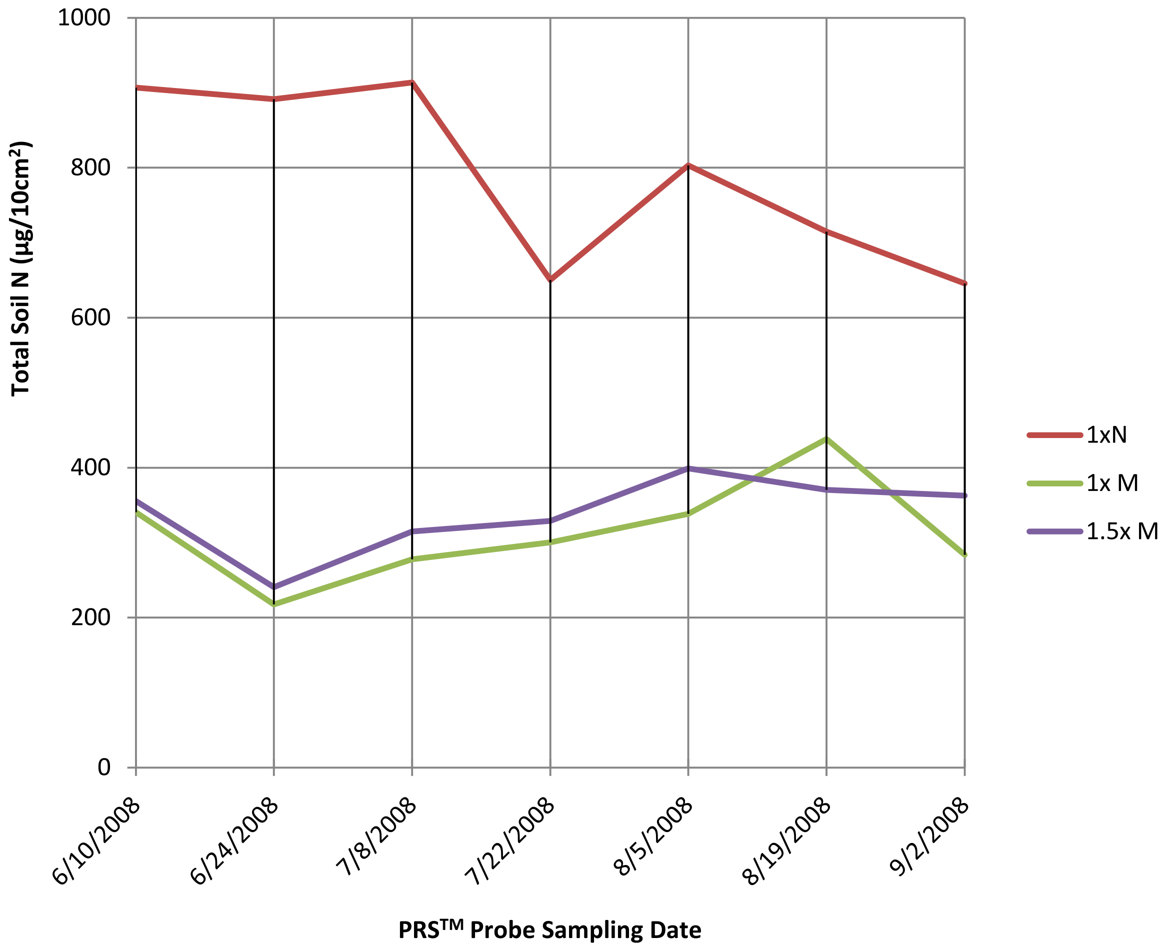
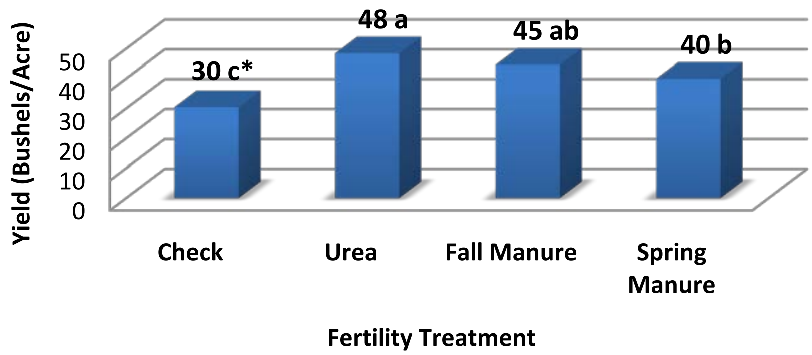
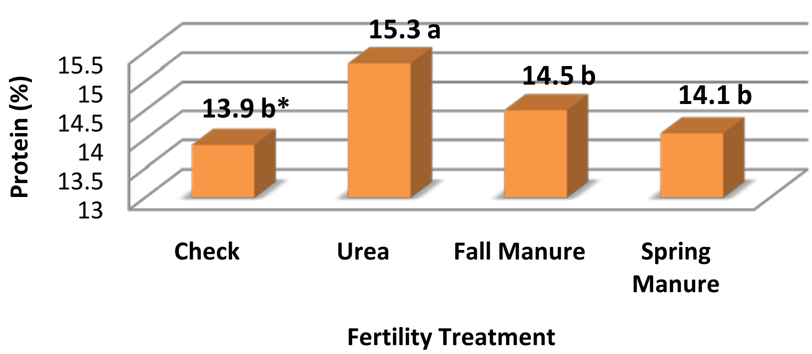


Figure 2. **Average wheat yield over 2 years using spring applied urea and spring and fall applied manure as the nitrogen source**



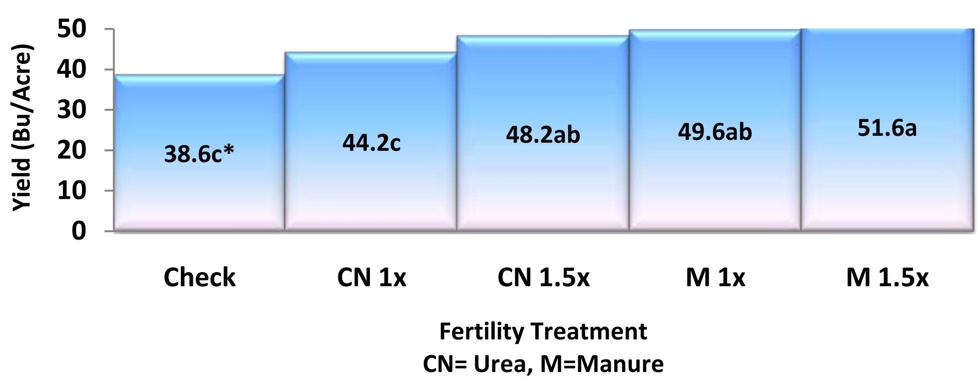
*Means followed by the same letter are not significantly different p=0.05

Figure 3. **Average wheat kernel protein over 2 years using spring applied urea and spring and fall applied manure as the nitrogen source**



*Means followed by the same letter are not significantly different p=0.05

Figure 4. **Wheat yield response to nutrient carry-over the second year after a fertility application**



*Means followed by the same letter are not significantly different p=0.05

Budget – Year 1

Research Technician salary and fringe benefits - $3,400

Travel - $600

Materials and Supplies - $1,400

Soil, manure and PRS probe analysis - $5,173

Total - $10,573