RESEARCH REPORT

ENVIRONMENT

Title: Cover crops, timing, and compaction: Evaluating practices to improve manure nitrogen management - **#17-183 IPPA**

Investigator: Daniel Andersen

Institution: Iowa State University

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Industry Summary

The impact of manure management on water quality is an important topic for Midwestern livestock producers and the sustainability of agriculture. Cover crops offer one potential option to improve nutrient utilization form livestock manure, but many questions remain on how to best integrate them into our manure management system. The timing of manure application relative to cover crop planting and growth is a common question of interest. This research work focuses on identifying and understanding how manure application timing relative to cover crop growth stage impacts their ability to retain nitrogen.

Keywords: manure, water quality, cover crops, manure timing, sustainability

Scientific Abstract

The addition of cover crop to agricultural systems has been stated to provide organic matter in the form of carbon to the soil, erosion control, and reduce the potential NO_3-N loss from the soil, which all contribute to successful and sustainable agriculture systems. In addition to the utilization of cover crop, Midwestern farmers can apply manure as fertilizer to add carbon, nitrogen, phosphorous, and potassium to the soil. One of the major concerns among farmers is the loss of nutrients, specifically NO_3-N. It can be lost to ground water as leachate, which is partly responsible for the hypoxic dead zone in the Gulf of Mexico. Through the combination of cover crop and the correct timing of manure application, the amount of nitrate lost into leached water can be reduced. The objective of this experiment was to find the optimal time to apply liquid manure, when combined with a winter rye cover crop. We compared the use of cover crop with various manure application timings (immediate, two, and four weeks after cover crop emergence), by the amount nitrate concentration in leached water. This study will provide guidance on how different manure application timing and the use of a cover crop can mintage nitrate loss to the environment.

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For more information contact:

National Pork Board • PO Box 9114 • Des Moines, IA 50306 USA • 800-456-7675 • Fax: 515-223-2646 • pork.org

Introduction

Agriculture is one of the largest industries in the Midwest region of the United States. The USDA reports that "more than 90 million acres of land are planted to corn, with the majority of the crop grown in the Heartland region" (USDA, Economic Research Service, 2018). In 2016, United States' crop cash receipts came to $194.4 billion (United States Department of Agriculture, Economic Research Service, 2018). It is crucial to investigate the methods in technology and equipment, to ensure that crop production is efficient and profitable. In addition, it is important to consider the impact that agriculture has on the environment and how much nitrogen and phosphorus transport occurs. Agricultural practices can impact environmental issues, such as soil erosion, water quality, and decreased soil organic matter (van der Werf and Petit, 2001). However, practices have been developed to mitigate these environmental concerns, with cover crops being one of the most widely considered.

Traditionally cover crops have been used to protect soil from erosion and the loss of nutrients (Dabney et al., 2001). These plants work to protect "cropland by intercepting the kinetic energy of rainfall and by reducing the amount and velocity of runoff" (Dabney *et al,* 2007). This soil is protected, the amount of soil erosion is reduced, and the amount of nitrogen contributed increases for the subsequent crop (Holderbaum *et al.*, 1990). The environmental performance of crop systems is enhanced, which has a direct influence on crop production and quality (Martinez-Feria et al., 2016).

There are several studies that support the idea that cover crops may be used to reduce NO3-N leachate, as highlighted in Dabney *et al.*'s literature review (Dabney *et al.,* 2007). When cover crops are planted, the loss of nitrate decreases (Everett *et al.*, 2018). Additionally, there are studies indicating that when planted after main crops, soil had higher organic matter and N mineralization relative to those without a cover crop (Moore, E.B. et al., 2014). Cover crops increase soil organic matter and increase carbon inputs, which increases soil efficiency (Dabney et al., 2001). Cover crops add organic matter to soil, improve the cycling of nutrients, and reduces nitrate leaching. The maintenance of nutrient levels is crucial for soil health and crop production. Cover crops have demonstrated the potential to enhance and improve each of these factors, making it an innovative practice in current agriculture (Schipanski et al, 2014).

In Iowa cropping systems, cover crops may be planted in the fall to grow over winter. During this time, the plants can trap nitrogen in the biomass of the cover crop, allowing it to be scavenged, rather than loss as leachate or volatilization (Miguez and Bollero, 2005, Hashemi, 2013). The common mineralization of this nitrogen is important to consider when developing sustainable systems. This makes the investigation of practices to reduce nitrogen loss important in agricultural systems.

Cover crops have the potential to capture the nutrients in animal manure, which improves the soil for crop production. Animal manure is considered an environmentally and economically friendly means of fertilization, as can both decrease the dependence on synthetic fertilizers, thus reducing the overall expense to farmers (Regan and Andersen, 2014). Animal manures improve soil structure and add nitrogen, phosphorous, and potassium, making it a key factor in sustainable agriculture and in our study (Andersen, 2013). Manure is typically applied in the fall, around October and November. It has been suggested to plant cover crops ahead of application, in order to retain as much nitrogen as possible. In our study, we found that the cover crop took approximately two weeks to emerge. When it has

emerged, it can provide most benefits. The question is when manure should be applied, relative to this growth. This is the recommendation we intend to give, based on our study.

Due to logistical constraints, there are concerns over compressed manure application windows in the fall. Incorporation of cover crops with this manure application can serve as a strategy to make sure negative environmental impacts are minimized. As a result of these concerns many farmer are interested in opportunities to utilize cover crops on their farms, but often question how to implement the practice most successfully, with questions about the order of logistics, planting cover crops and then applying manure or applying manure and then planting cover crops, a question they ask about which will be most effective for nutrient transport.

Objectives

Thus, the objective of this work is to evaluate how nitrate loss from soil columns was impacted by different manure application timing relative to cover crop growth stage to provide advice and reassurance to farmers about the effectiveness of using cover crops along with manure application.

Materials and Methods

The experiment was performed on Iowa State University's campus, in a laboratory in Sukup Hall. A structure made of wood and 6-inch PVC pipes was built to plant cover crop into. There were 18 columns, each filled with gravel rock to prevent soil washout, followed by approximately 2000g of soil. Winter wheat cover crop was planted into each column, aiming for at least 10 plants in each.

There were 6 treatments among the 18 columns: soil only, soil with cover crop only, soil with manure, cover crop with immediate manure application, cover crop with two-week delayed manure application, and cover crop with four-week delayed manure application, and column with soil only. Manure was applied at a rate to supply approximately 150 lb N/acre.

Every other week, the columns received 150-250ml water and allowed to fully drain into a glass bottle. When the columns were finished leaching, the mass of water in each glass bottle was weighed and recorded. A subsample of 50mL was collected into the corresponding labeled small plastic bottles. This was repeated for each sample. After all subsamples were collected, 5ml of 2M monoammonium phosphate ($NH_4H_2PO_4$) and 1 mL of nitrate stabilizing solution was added to each bottle and measured for nitrate concentration using an ion selective electrode.

Results and Discussion:

There was a total of six treatment levels: column with soil only, soil and cover crop, soil and manure, cover crop with immediate manure application, cover crop with two-week delayed manure application, and cover crop with four-week delayed manure application. This treatment structure allows isolation of factors of interest, including how cover crop impacted losses of nitrate from the soil, how application of manure modified losses, and then how cover crop growth stage relative to manure application timing impacted the potential for nitrogen loss.

Two soil types were used, with three replications of each soil type by treatment combination. Leaching events occurred every seven days with the experiment lasting for two months. Data analysis

was performed as a two factor analysis with soil being a random factor and treatment being a fixed effect.

The first part of the study evaluated where nitrogen loss was coming from, and then the effect at cover crops to mitigate that loss. Our results showed that fertilizer application increased nitrogen loss by about 32% in this study, or alternatively that 75% of the N loss was from the soil and only about 25% of the actual N loss came from the application of the fertilizer. This is on par with what we have seen in previous studies and also what other researchers have reported in field trials and illustrates part of the difficult with N management. That while fertilizer or manure application is important, soil process have a major impact. These results also illustrated that the use of cover crops on soil that didn't receive a fertilizer application resulted in approximately at 20% reduction in nitrate loss as the cover crop scavenged for the residual nitrate in the soil and held it within the soil profile (figure 1).

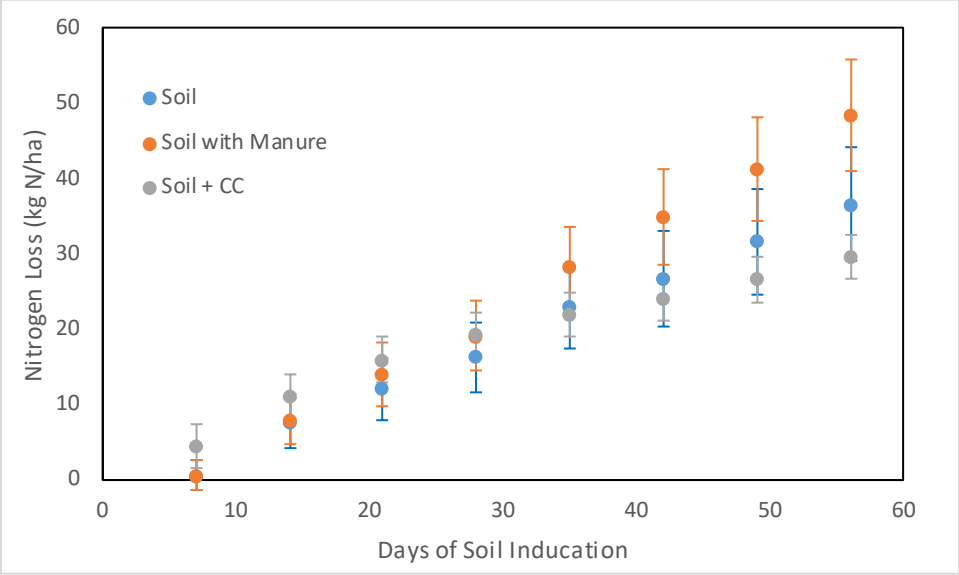

Figure 1. Cumulative nitrogen loss from soil only, soil with a cover crop, and soil receiving 150 lb N/acre of nitrogen from liquid swine manure.

In terms of using cover crop with the manure application timing, only the four week after emergence timing showed a reduction in nitrogen loss. In part, this could be due to the delay in actually timing of nitrogen application, as it had a shorter time to react in the soil and be nitrified before the leaching occurs. Interestingly though, the pronounced difference in N loss doesn't occur early in the incubation, but rather later in the incubation, indicating it may be more related to cover crop growth stage than to the delay in nitrogen timing. To better understand this effect, we examined the first two weeks of nitrogen loss and the month of nitrogen loss after manure application, removing the effect of application timing and focusing exclusively on the cover crop growth stage effect (figure 3). The results clearly illustrated that having the cover crop up and growing at the time of application reduced nitrogen leaching, presumably because it both created a drier soil that was less prone to leaching, but also due to the more vigorous cover crop growth that increased plant incorporation and reduced the potential to leach.

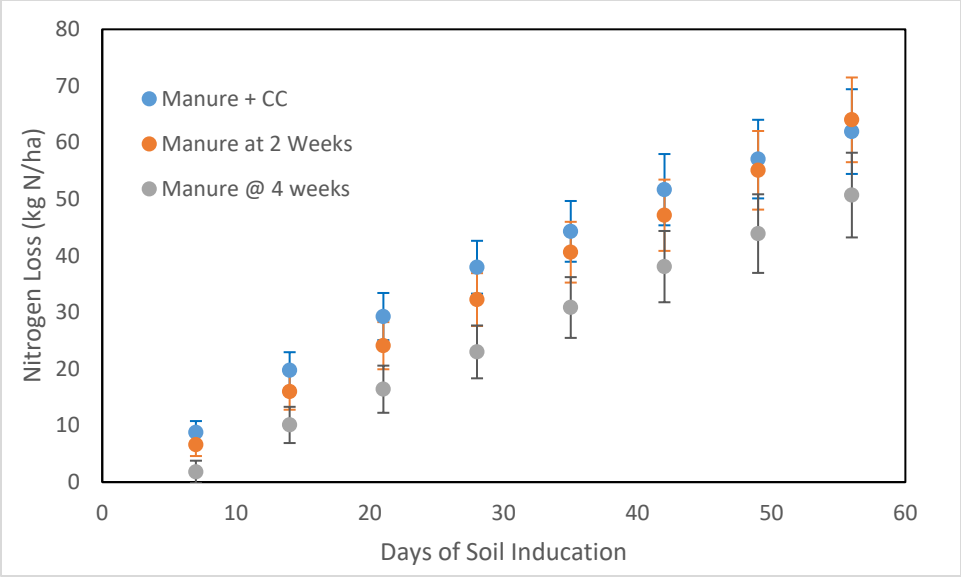

Figure 2. Comparison of nitrogen loss from manure with different timing relative to cover crop growth stage.

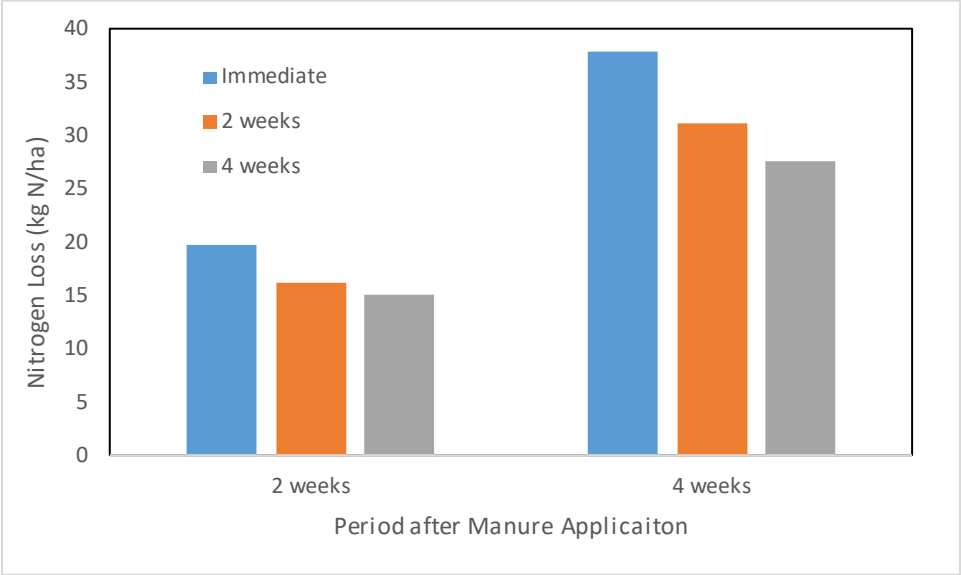

Figure 3. Leaching of nitrogen based on cover crop growth stage at time of application.

Conclusions:

Our results indicated that the use of cover crops reduced nitrogen loss from both the soil and manure, and that application timing, both in general, and relative to cover crop growth impacted the potential for nitrogen loss. In particular, we saw that having greater cover crop growth stage at the time of manure application created a situation where the cover crop was more actively growing and allowed greater nitrogen tie up and immobilization, reducing the potential for nitrogen leaching.