Use of a Nitrification Inhibitor to Improve Crop Recovery of Manure Nutrients

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Abstract

Intensive hog operations generate large amounts of manure that must be dealt with in a manner that is both economically and environmentally sound. The objective of the research described is to evaluate the effect of adding a nitrification inhibitor as means of enhancing crop recovery of manure nitrogen. A long - term swine manure field trial located on a Black Chernozem (Cudworth Association) near Dixon, SK was used in the study. A nitrification inhibitor (DCD) was added to liquid swine manure that was applied using low disturbance injection in the spring of 2005. The application rate of nitrogen in this treatment was ~ 75 kg $N \cdot ha^{-1}$ per year. This was compared to the same rate of liquid swine manure applied without the inhibitor. The efficacy of the nitrification inhibitor was evaluated by measurement of plant nitrogen recovery. As well, PRS^{TM} probes (anion and cation exchange membranes) were used to assess ammonium and nitrate supply rates in the soil during the growing season as affected by treatment. Plant samples were also taken biweekly during the growing season to quantify biomass production and measure plant nitrogen uptake in the selected treatments. Data obtained in the 2005 season indicates that the nitrification inhibitor was effective in keeping more of the manure nitrogen in the ammonium form during the 2005 season at the Dixon site. However, significant increases in crop nitrogen recovery, and yield responses were not observed from the use of the nitrification inhibitor at the Dixon site. This may be explained by conditions during the growing season that were not conducive to high potential losses of nitrate by leaching or denitrification.

Introduction

Intensive hog operations are capable of generating large amounts of manure. This manure must be dealt with in such a way that is economical and environmentally friendly. Previous work has been done in the area of phosphorus and nitrogen loading (Stumborg C.M. et al. 2005). The focus of this experiment is to examine possible ways of increasing the plant uptake of manure nitrogen applied to the soil. The goal is to use the nitrogen supplied in the manure more efficiently.

Hypothesis and Objective

The hypothesis of the experiment is that the addition of a nitrification inhibitor to swine manure will lead to an increased recovery of manure nitrogen. The objective is to

evaluate the role of a nitrification inhibitor as a means to increase the utilization of manure nitrogen by crops

Materials and Methods

The experimental site was located at Dixon, Saskatchewan. The soil at the Dixon site is a Black Chernozem of the Cudworth Association, with a loamy surface texture formed on silty lacustrine material. Test plots were 30.5 meters long by 3.05 meters wide. The experiment was a randomized complete block design (RCBD) replicated 4 times. Hard red spring wheat (Intrepid) was the crop grown during the 2005 growing season. The treatments of interest were the control, 1X and 1X + nitrification inhibitor.
The control treatment did not receive any manure or fertilizer. The 1X treatment represents the one times recommended agronomic rate of 37,000 L ha^{-1} of swine manure. The nitrification inhibitor used in the experiment was Super N Concentrate. Super N Concentrate contains both a nitrification and urease inhibitor. Dicyandiamide (DCD) is the nitrification inhibitor and N-(butyl) thioshosphoric triamide (NBPT) is the urease inhibitor. It was anticipated that the majority, if not all of the inhibition, will be from the DCD, as all or most of the urea in the manure would have already undergone hydrolysis by the time of manure application. Soil samples were taken for the treatments of interest prior to manure application. Plant samples were taken biweekly until the crop reached the dough stage. Biweekly plant samples allowed for determination of nitrogen uptake over time. PRS probes were placed in the soil two weeks after seeding. PRS probes were removed and replaced every two weeks throughout the growing season, which allowed for monitoring of nitrogen supply rates. Four anion and four cation PRS probes were placed in treatment plots of interest. The PRS probes were placed in PVC cores in an attempt to exclude root competition. All manure fertilizers were injected into the soil with Bourgault coulter openers.

Results and Discussion

Supply rates of ammonium in the soil over five two week time periods throughout the growing season are shown in Figure 1. The manure fertilizer treatment that received the nitrification inhibitor revealed significantly more nitrogen supplied in the ammonium form as compared to the treatment that did not receive the inhibitor. This shows that the inhibitor is keeping the nitrogen in the ammonium form longer, and preventing the conversion of ammonium to nitrate.

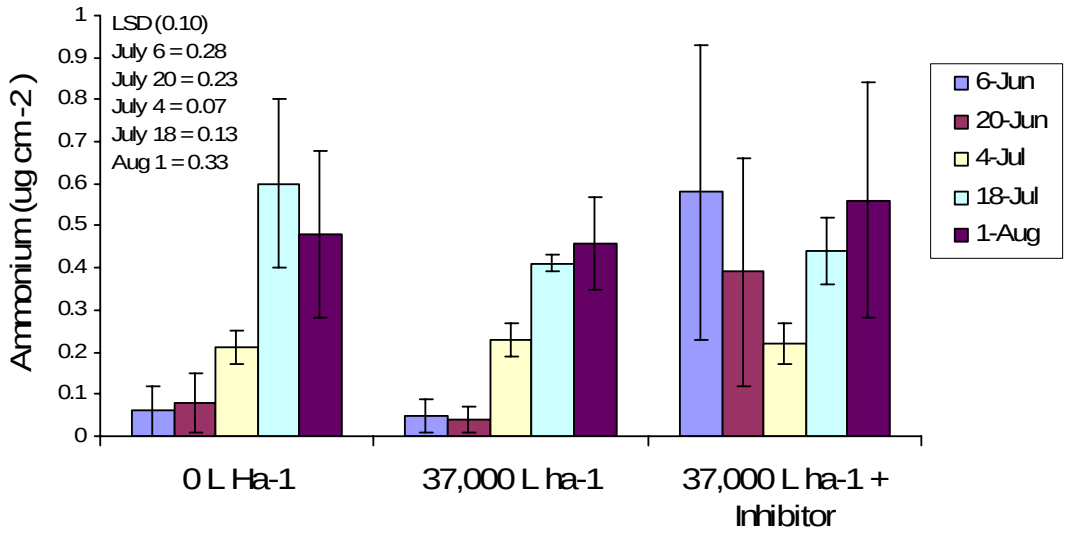

Figure 1. Ammonium supply rate for three manure treatments over time.

Supply rates of nitrate over five two week time periods were highest in the 37,000 L h^{-1} treatment (without nitrification inhibitor), and slightly lower in the 37,000 L h^{-1} + nitrification inhibitor (Figure 2). Lower supply rates of nitrate are expected from the 37,000 L h^{-1} + nitrification inhibitor treatment as the conversion of ammonium to nitrate is slowed.

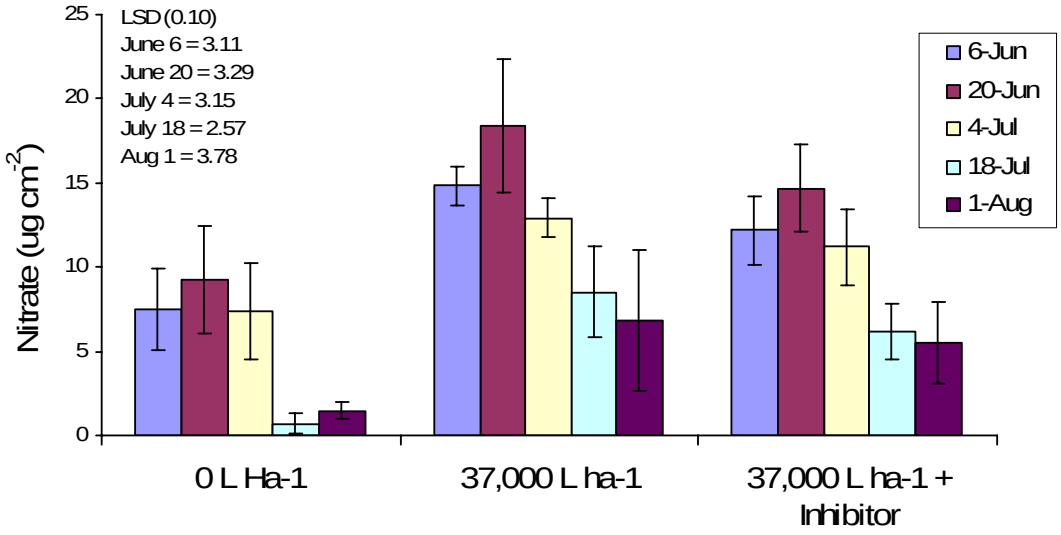

Figure 2. Nitrate supply rate for three manure treatments over time.

There were no significant differences in biomass production over the growing season between the manure treatments until the last sampling period (Figure 3). Slightly higher biomass production was observed in the 37,000 L h^{-1} + nitrification inhibitor treatment as compared to the 37,000 L h^{-1} treatment without the inhibitor on the last sampling date.

The higher biomass production may be related to the addition of the nitrification inhibitor.

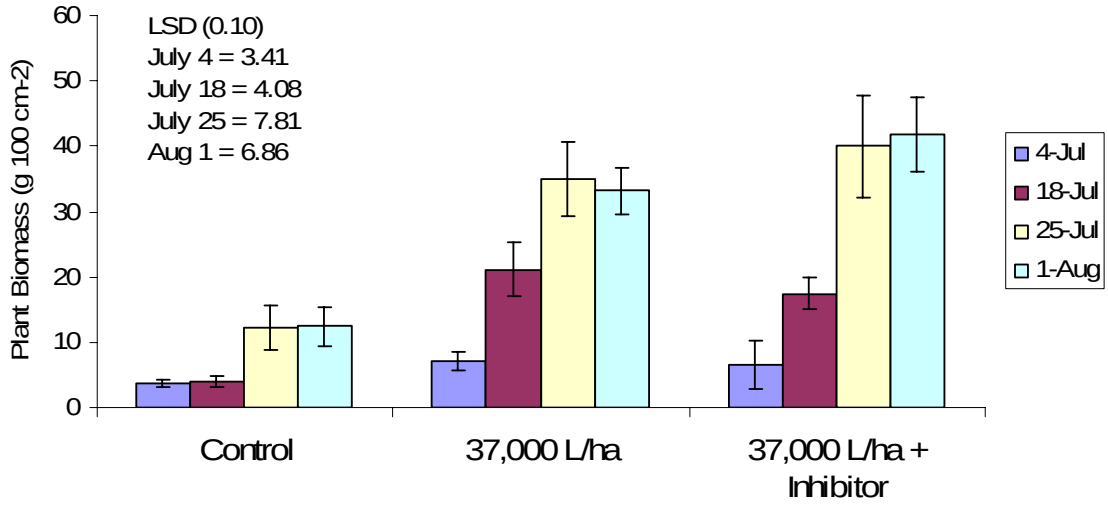

Figure 3. Plant biomass production for three manure treatments over time.

Nitrogen uptake was calculated using the biweekly biomass samples collected during the growing season. Data was then normalized to make the N uptake of unfertilized control equal to 100% uptake. The N uptake in the 37,000 L ha^{-1}, and 37,000 L ha^{-1} + nitrification inhibitor treatments are shown relative to the uptake of the controls for their respective sampling dates (Figure 4). No significant effects in nitrogen uptake were observed, with the exception of July 25 sampling date. The increase in nitrogen uptake on July 25, could be the effect of the nitrification inhibitor on conserving more N.

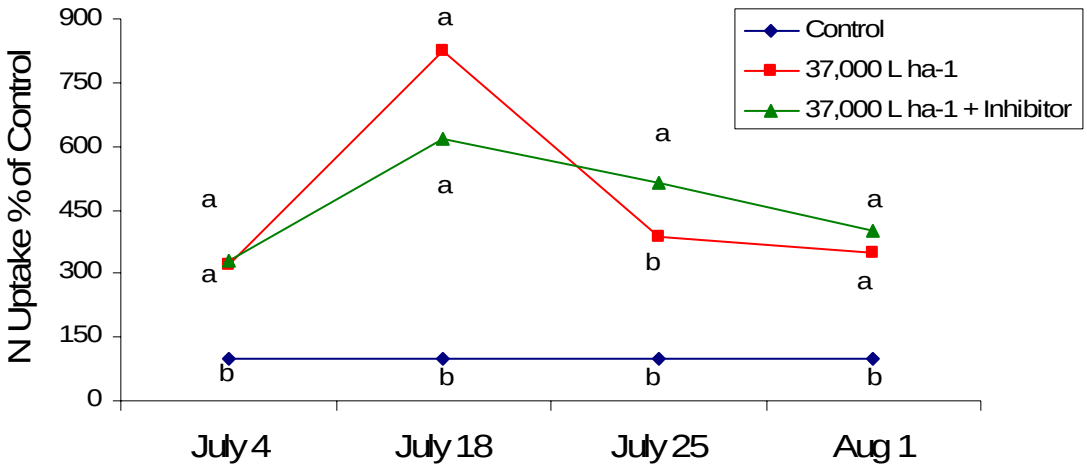

Figure 4. Normalized data of nitrogen uptake of three manure treatments as a percent of control over time. Data is presented as a percent compared to control.

In terms of final gain yield (Figure 5) no significant differences were observed between the 37,000 L ha^{-1} and 37,000 L ha^{-1} + nitrification inhibitor treatment in the 2005 field season.

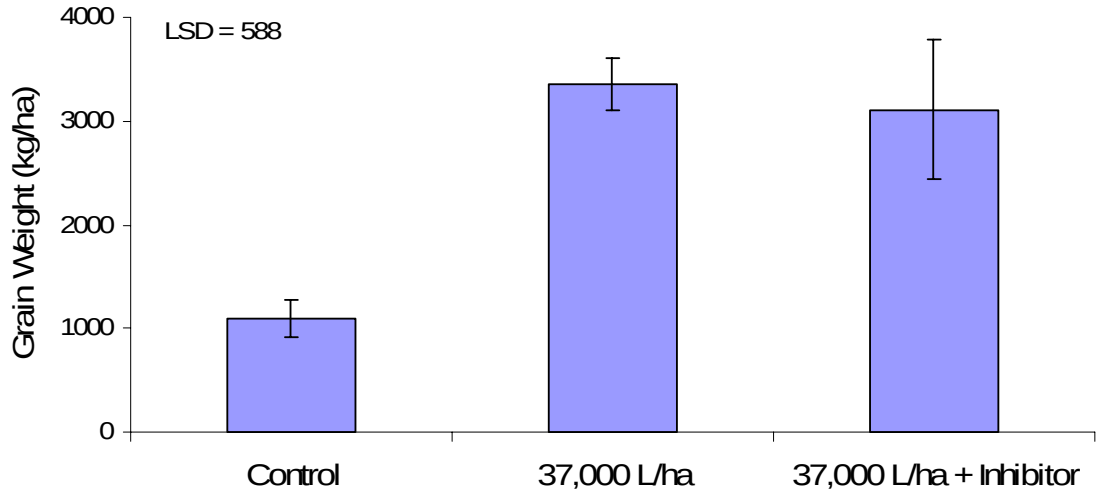

Figure 5. Grain yield production for three manure treatments for the 2005 growing season at Dixon experimental site.

Discussion

The addition of a nitrification inhibitor to swine manure was effective in maintaining nitrogen in the ammonium form longer compared to manure that had not received the inhibitor. In a fertilizer study using a dicyandiamide and urea fertilizer Gioacchini et al. (2002) found that the use of a nitrification inhibitor can maintain nitrogen as ammonium for a longer time compared to urea that is left untreated. Vallejo et al. (2005) found that soil ammonium concentrations declined less rapidly in swine manure treatments which received a nitrification inhibitor added to the manure. Overall the nitrification inhibitor appears to be effective in maintaining nitrogen in the ammonium form longer early in the growing season, but no significant increase in grain yield were observed in the 2005 growing season.

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