MinnesotaCorn
RESEARCH & PROMOTION COUNCIL

FINAL REPORT

PROJECT TITLE: Effects of time of N application and Instinct on corn production and nitrate losses from tile drainage water.
PROJECT NUMBER: 4105-13SP
PRINCIPAL INVESTIGATOR AND CO-INVESTIGATOR(S): Jeffrey Vetsch and Dr. John Lamb

ABSTRACT

Fall is a desirable time to apply nitrogen (N) fertilizer for corn in south-central Minnesota; however, the potential for N loss is greater with fall application. A research study was conducted to determine if adding a nitrification inhibitor to fall and spring-applied N fertilizers could increase corn grain yield and/or reduce N loss to tile drainage. The objective of this study was to measure the agronomic and environmental effects of adding the nitrification inhibitor Nitrapyrin (Instinct, Dow AgroSciences) to spring and fall-applied urea and sidedress-applied UAN. Spring-applied urea or split-applied UAN had 22 bu/ac greater grain yields than fall-applied urea in 2 of 4 years in this study. Fall-applied urea had slightly greater grain yields than spring urea in 1 of 4 years. The addition of Instinct to fall-applied urea increased grain yield and reduced NO_3 concentration and loss in tile drainage water in 1 of 4 years. Fall-applied urea resulted in 38% greater NO_3 loads to tile drainage water than did spring urea. These data do not support the application of fall-applied urea with or without Instinct in south-central Minnesota.

INTRODUCTION

Fall is a desirable time to apply N fertilizer for corn in the northern Corn Belt. Generally, more time is available in the fall for the farmer or custom applicator, soils are drier, compaction is less, and time is saved for earlier spring planting. About 75% of the N taken up in a corn plant occurs during the months of June and July. The period of time between fall N application and N uptake is of concern as significant N loss can occur as a result of denitrification and/or leaching. Therefore, the potential for N loss is greater with fall application. Nitrogen loss contributes to NO_3-N contamination of ground and surface waters, reduced grain yields and profitability for the producers, and results in poor N use efficiency.

In south-central Minnesota, anhydrous ammonia (AA) is recommended as the N source for fall application when applied in late October and November. Urea is not recommended for fall application based on research conducted from the late 70's through the early 90's. This research showed corn grain yields were reduced substantially when urea was applied in late October. In recent years, urea has become a more popular choice of N for both dealers and farmers; therefore, interest exists among both parties to be able to fall-apply urea without the risk of losing N, grain yield, and profit. Research (Randall et al., 2005) has shown adding the nitrification inhibitor nitrapyrin (N-Serve™) to fall-applied AA increased corn grain yields on poorly drained soils in south-central Minnesota. Can the addition of a nitrification inhibitor to fall-applied urea reduce N loss and increase corn yields?

OBJECTIVE AND GOAL STATEMENTS

The objective of this study was to evaluate the effects of the nitrification inhibitor Instinct™ (Dow AgroSciences) added to spring and fall-applied urea and sidedress-applied UAN on corn yield, N use efficiency, NO_3-N concentration and losses in tile water, and residual soil N. The goal of this project was to collect new research data and then to use these data to educate Minnesota farmers on the agronomic performance and environmental consequences of fall urea application in south-central Minnesota.

MATERIALS AND METHODS

This research project was conducted on the tile drainage research facility at the Southern Research and Outreach Center. The field design simulates a50 ft tile drain spacing. The site is a poorly drained Canisteo-Webster clay loam soil formed in glacial till. Nineteen treatments were established in the fall of 2011. Eighteen of the treatments comprise a factorial arrangement of three N management factors at various levels. These factors include: N timing/source [fall-applied urea, spring-applied urea and split-applied UAN (20 or 30 lb N/ac at planting plus V4 sidedress)], N rate (160, 200 and 240 lb N/ac) and nitrification inhibitor (0 and 35 or 37 oz/ac of Instinct or Instinct II). The 200- and 240-lb rates are greater than University of Minnesota recommendations to: 1) insure having an N rate which maximizes grain yield and 2) better delineate treatment differences in NO_3-N concentration and loss in tile drainage water. A zero N control treatment was also included to better quantify N contributions from soil. Eight of the N treatments were located on tile drainage plots. The tile drainage plots included: 0-lb N control, all combinations of N timing/source and Instinct at the 200 lb N/ac rate, and the spring-applied urea with Instinct at 160 lb N/ac treatment. All treatments were replicated four times in a randomized, complete block design.

Fall and spring urea and Instinct treatments were broadcast-applied and incorporated with tillage within 24 hours after application. The split-applied UAN treatments were surface dribbled banded two inches to the side of the corn row at planting. At V4, sidedress UAN was stream injected mid-row with and without Instinct at or Instinct II. Stover yields were taken from a 15-ft segment of row at physiological maturity (R6). Grain yields were measured by combine harvesting the center rows and are reported at 15.5% moisture. Corn stover and grain samples were dried, ground, and analyzed for total N. Yield and N concentration data were used to calculate N uptake and nitrogen use efficiency (NUE) parameters.

Tile flow volume was tabulated daily by totaling flow meter readings for the previous 24-hr period at 0800 each morning. A flow-weighted water sample was collected twice a week during significant flow events and once a week during other times. In the field, water samples were kept cool until collected; then they were frozen. The water samples were analyzed for NO_3-N concentration by RAL. Total NO_3-N lost was calculated by multiplying the NO_3-N concentration of each sample by the total calculated flow for the same period. Flow-weighted average NO_3-N concentrations were calculated by taking the total NO_3-N lost for a period (month) and dividing by total flow volume for the same period. Flow normalized NO_3-N losses are calculated by taking the annual total NO_3-N lost and dividing by the total flow in each plot.

Post harvest soil samples were taken from all plots to a four foot depth in one foot increments with a hydraulic probe. All samples were dried at 125º F, ground, sieved to pass a 2-mm screen, and analyzed for NO_3-N and NH_4-N.

RESULTS AND DISCUSSION

Results were greatly influenced by the weather, which was unique for each year of the study; therefore, the results for each year will be discussed individually. Results in 2012 were influenced by the warm fall of 2011, a very warm March, a wet May and a summer drought. Corn grain and silage yields were less than normal, caused by very dry conditions starting in July, and were not affected by the main effects of N source/timing and Instinct in 2012. Corn grain yields were 8–10 bu/ac greater with the 240 lb N/ac rate compared with the 160 and 200 lb N/ac rates, when averaged across N source/timing and Instinct treatments. Numerically, N recovery was greatest with spring applied urea, intermediate with split-applied UAN and least with fall urea. However, differences in NUE parameters were small and not consistent among all the parameters. Tile drainage totaled 2.0 and 1.9 inches in May and June, respectively. Flow weighted NO_3-N concentrations in May, June and the annual average were greater with fertilized treatments compared with the control (zero N) treatment and concentrations were greater with fall urea compared with spring urea. Averaged across N treatments, annual total NO_3-N losses from tile drainage in 2012 were less than 5 lb NO_3-N/ac. These low values were similar to values obtained in the drought years of 1987 and 1988. After harvest, residual soil NO_3-N (RSN) was greatest with split-applied UAN, intermediate with spring-applied urea and least with fall-applied urea.

A wet spring, where precipitation was 8.56 inches greater than normal from March through June, greatly influenced corn production and nitrogen losses in tile drainage in 2013. Corn grain yields were greater with spring urea (189 bu/ac) compared with fall urea (167 bu/ac) and split-applied UAN (172 bu/ac), when averaged across the main effects of N rate and nitrification inhibitor. Grain yields were greater with the 240-lb N rate (181 bu/ac) compared with the 160-lb rate (170 bu/ac) but not greater than the 200-lb N rate (176 bu/ac). Corn grain and silage yields were not affected by the main effect of Instinct. However, a significant N source/timing × Instinct interaction for grain yield showed: 1) corn grain yields were 9 bu/ac greater with Instinct when urea was fall-applied; 2) yields were numerically greater (6 bu/ac) with Instinct when urea was spring-applied; and 3) yields were numerically less (7 bu/ac) with Instinct when UAN was split-applied. Total N uptake was greatest with spring applied urea and split-applied UAN compared with fall urea; whereas, apparent N removal and NUE were numerically greatest with spring urea, intermediate with split-applied UAN and least with fall urea. The annual total tile drainage averaged across treatments was 13.9 inches in 2013, nearly 10 inches more than in 2012. Ninety-one percent of the total tile flow occurred in the months of April, May and June. For all months and the annual average, flow-weighted NO_3-N concentrations were greater with fall urea compared with spring urea and split-applied UAN. In May and the annual average, NO_3-N concentrations were less with the nitrification inhibitor Instinct compared to without Instinct, when averaged across N source/timing. Flow normalized NO_3-N losses ranged from 0.83 lb NO_3-N/inch of drainage with the control to 6.62 lb NO_3-N/inch with fall urea without Instinct. Flow normalized NO_3-N losses were greater with fall urea compared with spring urea and split-applied UAN. After harvest, residual soil NO_3-N was not affected by the main effects of N timing/source and Instinct. However, RSN increased with increasing N rate.

A cool and wet spring with record June precipitation resulted in poor yields and considerable nitrogen loss in tile drainage in 2014. Corn grain yields were greater with split-applied UAN (152 bu/ac) than with spring urea (134 bu/ac) and fall urea (130 bu/ac). Grain yields were greater with the 240-lb N rate (147 bu/ac) compared with the 200-lb (135 bu/ac) and 160-lb (133 bu/ac) rates. Corn grain and silage yields were not affected by the main effect of Instinct. Nitrogen concentration, uptake and NUE parameters were greater with split-applied UAN compared with fall- and spring-applied urea, but were not affected by Instinct. Averaged across N treatments, tile drainage totaled 15.2 inches in 2014, which was 1.3 inches more than 2013 (also a wet year). Ninety-nine percent of the total tile flow occurred in the months of April, May and June; moreover, 63% of the total flow occurred in June. Flow weighted NO_3-N concentrations were greater with fall-applied urea than with spring urea and split-applied UAN in all months except May were fall urea was only greater than spring urea. Flow normalized NO_3-N losses ranged from 1.03 lb NO_3-N/inch of drainage with the control to 5.20 lb NO_3-N/inch with fall urea without Instinct. Flow normalized NO_3-N losses were greater with fall urea compared with spring urea and split-applied UAN. Nitrate-N concentrations and losses were not affected by the nitrification inhibitor Instinct in 2014. Residual soil NO_3-N was greater with split-applied UAN compared with spring- or fall-applied urea and RSN generally increased with increasing N rate.

The 2015 growing season was ideal for corn production in Waseca County. A warm and dry early spring and fall allowed for early and timely field operations, while summer had ample and well distributed rainfall. Corn grain yields were greatest with fall-applied urea (221 bu/ac), intermediate with spring urea (213 bu/ac) and least with split-applied UAN (202 bu/ac). Grain and silage yields were greatest with the 240-lb N rate (221 bu/ac), intermediate with the 200-lb rate (215 bu/ac) and least with the 160-lb N rate (200 bu/ac). Corn grain and silage yields were not affected by the main effect of Instinct. Total N uptake was greater with fall-applied urea than with spring urea and split-applied UAN. Apparent N recovery and removal and NUE were numerically greatest with fall urea, intermediate with spring urea and least with split-applied UAN. The annual total tile drainage was 13.3 inches in 2015, which was similar to 2013. Forty-two percent of the total tile flow occurred in the months of April, May and June. Flow-weighted NO_3-N concentrations in May, August, September, November and the annual average were greater with fall-applied urea compared with spring urea and split-applied UAN. The annual average NO_3-N concentration was 22% greater with fall-applied urea than with spring urea and split-applied UAN. Monthly flow-weighted NO_3-N concentrations were not affected by the main effect of the nitrification inhibitor Instinct in 2015. Flow normalized NO_3-N losses ranged from 0.79 lb NO_3-N/inch of drainage with the control to 4.83 lb NO_3-N/inch with fall urea without Instinct. Flow normalized NO_3-N losses were much greater with fertilized treatments compared with the control treatment and losses were about 23% greater with fall urea than with spring urea and split-applied UAN. Residual soil NO_3-N was slightly greater with fall-applied urea than with split-applied UAN and RSN was greatest with the 240-lb rate.

The yield, N uptake and soil N results for 2015 were favorable for fall-applied urea, which is somewhat surprising when considering the wetter-than-normal growing season and how poorly fall urea performed in 2013 and 2014 in this study. A dry winter and early spring left a soil moisture deficit for the 2015 growing season which likely minimized the potential for loss of fall-applied N prior to the V6 growth stage. The 2015 yield and spring soil data suggested: 1) fall-applied urea may have enhanced N mineralization from organic matter, and/or 2) spring-applied N may have been more susceptible to denitrification or immobilization because of it is placement near the soil surface. Fall-applied urea did result in significantly greater N losses in tile drainage water in 2015, which was consistent throughout this study.

CONCLUSIONS

On this glacial till soil corn grain yields with fall-applied urea were: A) similar to spring-applied urea in the drought year of 2012; B) 22 bu/ac less than spring-applied urea in the wet year of 2013; C) 22 bu/ac less than split-applied UAN in 2014, which had a record wet June; and D) 8 bu/ac greater than spring-applied urea in 2015. Adding the nitrification inhibitor Nitrapyrin as Instinct or Instinct II to fall-applied urea increased grain yield and reduced NO_3-N concentration and loss in tile drainage water only in 2013. Fall-applied urea resulted in 38% greater NO_3-N loads to tile drainage water than did spring urea, when averaged across the 2013, 2014 and 2015 drainage years. Fall-applied urea with or without Instinct can result in substantially lower corn grain yields and consistently greater NO_3-N loading in tile drainage water; therefore, fall-applied urea is not recommended in south-central Minnesota. This study found no difference in NO_3-N concentration or loading between the 160- and 200-lb N/ac rates of spring-applied urea with Instinct and corn grain yields were greater with 200 lb N/ac than with 160 lb N/ac in 2 of 4 years. These data support the recent N rate increase for non irrigated continuous corn published by Kaiser and Fernandez on 2 April, 2016. Based on these data a split application of UAN (30-lb or less as starter and rest at V4) would not be recommended for continuous corn on glacial till soils in Minnesota. These low rates at planting coupled with a between-the-row sidedress application did not provide enough N for early crop growth and development in 3 of 4 years of this study.

EDUCATION, OUTREACH, AND PUBLICATIONS

These data have been presented at the following meetings: 4R Drainage Workshop (March 3, 2016 in Denver, 20 in attendance), The Nitrogen Conference (February 23, 2016 in Rochester, 130 in attendance), Winter Crops Days (January 14 and 15 at four locations in southern MN, 208 in attendance), Minnesota Ag Expo, poster (January 27 and 28, 2016; January 29, 2015 and January 9, 2014 all in Mankato). The PI has also presented this information to the MCR&PC on two occasions (March 27, 2013 and June 10, 2014).

REFERENCES

Kaiser, D. and F. Fernandez. 2016. Updates to Corn Fertilizer guidelines for 2016. Online: http://blog-crop-news.extension.umn.edu/2016/04/updates-to-corn-fertilizer-guidelines.html

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