The Effects of Swine Manure Application Timing and Nitrapyrin on Corn Yield and Nitrogen Availability

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Introduction

In the northern Corn Belt swine manure is generally applied in the fall. The time between fall manure application and nitrogen (N) uptake in corn is concerning as significant N loss can occur due to leaching and denitrification. Swine manure contains more ammonium (NH_4^+) compared with other manure sources. Ammonium nitrifies rapidly when soil temperatures are warm. Once the manure N is nitrified to nitrate (NO_3^-), it can be lost. Therefore, the potential for N loss from swine manure is greater when fall-applied. Nitrogen loss contributes to NO_3 contamination of ground and surface waters, reduced yields, and profitability for farmers and results in poor N use efficiency. Delaying application of swine manure until soils are cool (early November in Minnesota) and adding a nitrification inhibitor, like Instinct™ (nitrapyrin, Dow AgroSciences), should slow the rate of nitrification in manure, thereby reducing the potential for N loss.

Objective

To determine the effects of manure application timing and Instinct (nitrapyrin) rate on corn (maize) grain yield, N availability and N distribution in the soil profile.

Methods

Field experiments were conducted from 2010 through 2013 on clay loam (Typic Endoaquolls) soils in south-central (Waseca) Minnesota. Six treatments consisted of two manure application timings [early October and early November] and three rates of nitrapyrin as Instinct™ [0, 0.56 and 1.12 kg ai ha^{-1} (0, 35 and 70 oz ac^{-1} of Instinct)]. Liquid swine manure was sweep injected 10-15 cm deep in bands spread 75-cm apart at a rate to obtain 134 kg of available N ha^{-1} based on 80% availability of the total N in manure (Hernandez and Schmitt, 2012). Additional treatments included anhydrous ammonia applied in early November at 134 kg N ha^{-1} and a zero N control. Soil samples were taken to characterize each site. Soil test P and K were at very high levels (Kaiser et al., 2011) and no additional P or K fertilizer was applied. Sulfur as gypsum was applied at 17 kg ha^{-1} to all plots. Corn was planted at 86,000 seeds ha^{-1} in late April or early May. Corn grain yields were taken from the center two rows of the 4-row wide plots with a research combine. In the fall prior to soil freeze-up, soil samples were taken through the manure bands to a 30-cm depth. These samples were analyzed for NO_3-N and NH_4-N concentration to determine the rate of nitrification of manure N.

Analysis of variance was performed using the Proc Mixed procedure in SAS (SAS® 9.2, SAS Institute). A mixed model with block as a random effect and manure and Instinct treatments as a fixed effects was fitted to the data. A log transformation of soil NO_3-N and NH_4-N data was used prior to statistical analysis because an initial analysis indicated a non normal distribution. When the transformation was used the inferences are based on the geometric mean instead of the arithmetic mean. Alpha=0.10 level of significance was used to determine differences in treatment means.

References

Hernandez, J.A. and M.A. Schmitt. 2012. Manure management in Minnesota. Ext. Publ. WW-03553. Univ. of Minnesota.

Kaiser, D.E., J.A. Lamb and R. Eliason. 2011 Fertilizer guidelines for agronomic crops in Minnesota. Ext. Publ. 06240-S Univ. of Minnesota.

Fall application of manure (left) and anhydrous ammonia (right) in 2011.

Acknowledgement

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Results

Table 1. Normal monthly precipitation and air temperature and departures from normal for the study period (study period starts with October application and runs through harvest in September of the next year).

Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Monthly precipitation, mm											
Normal†	68	55	38	32	25	63	82	100	119	112	121	93
	Departure from normal precipitation, mm											
2010-11	-42	8	56	-5	9	-8	32	19	13	71	-97	-71
2011-12	-57	-47	-4	-12	33	-14	-3	46	-11	-59	-84	-69
2012-13	-33	-39	7	-15	10	27	76	64	50	22	-68	-44
	Monthly mean air temperature, C											
Normal	9.0	0.4	-7.9	-10.4	-7.5	-0.4	7.8	14.8	20.3	22.2	21.0	16.3
	Departure from normal air temperature, C											
2010-11	1.6	0.3	-2.7	-3.1	-1.9	-2.4	-1.3	-0.9	0.1	2.4	0.1	-0.9
2011-12	1.7	2.0	3.8	4.6	4.3	8.8	0.9	2.2	0.7	2.7	-0.7	-0.9
2012-13	-1.6	1.6	2.1	1.2	-1.1	-4.1	-4.3	-1.8	- 0.7	0.0	-0.1	1.7

† 30-yr normal period (1981-2010)

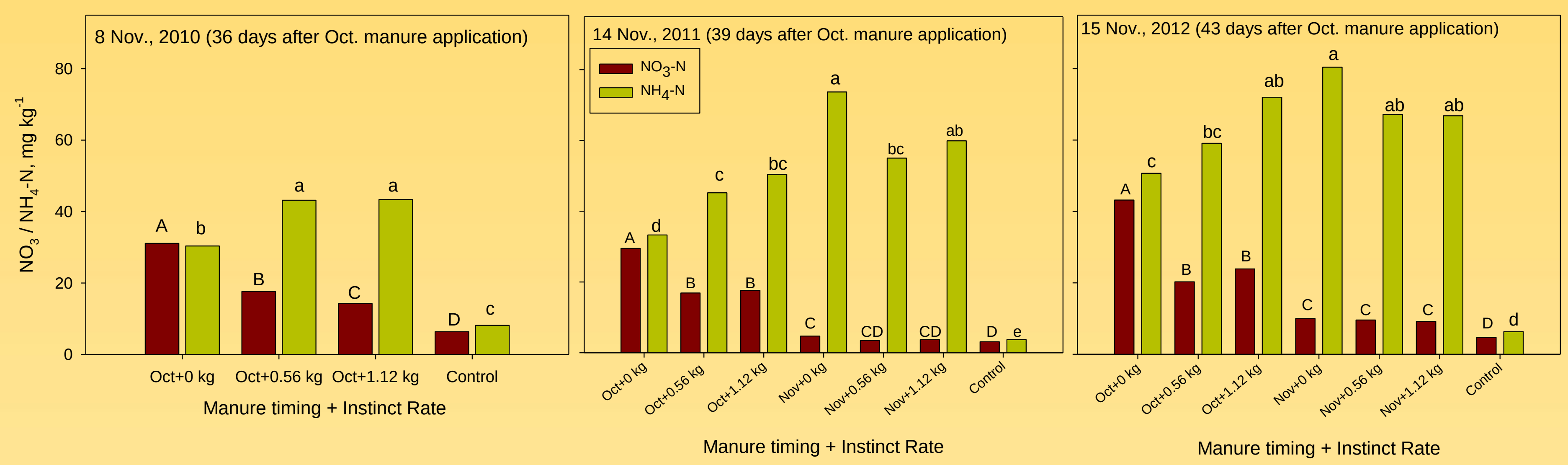

Figure 1. Soil NO_3-N and NH_4-N concentrations in manure bands about 40 days after October manure application [significant differences for NO_3-N (CAPITAL letters) and NH_4-N (lower case letters)].

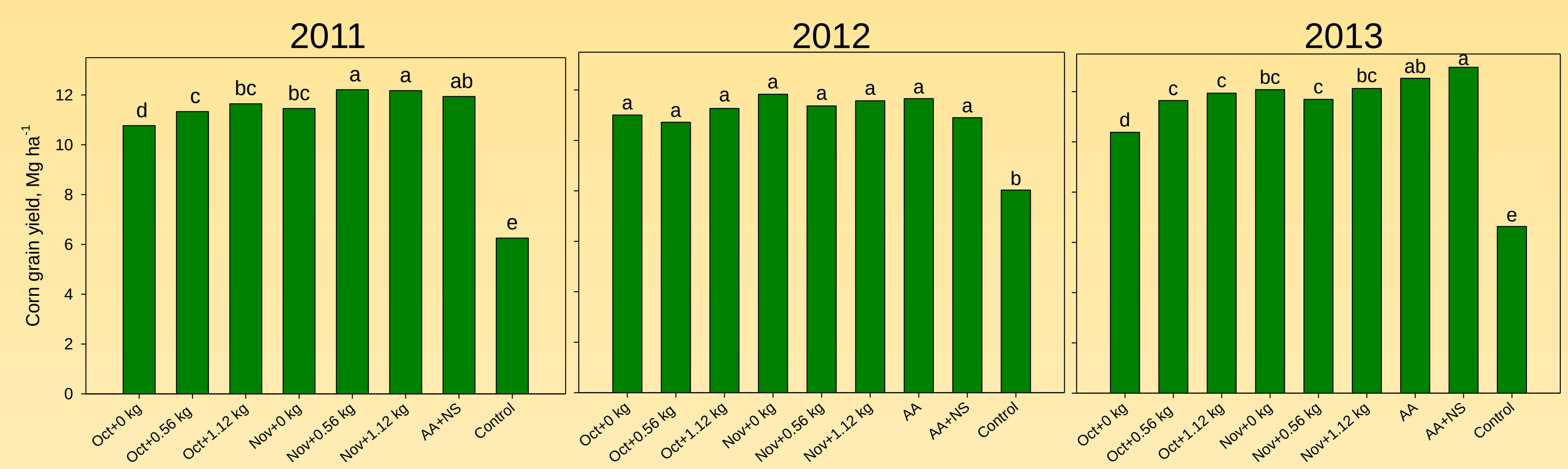

Figure 2. Corn grain yields as affected by manure, fertilizer and nitrification inhibitor treatments (AA=anhydrous ammonia, NS=N-Serve™).

Table 2. Corn grain yields as affected by the main effects of manure application timing and Instinct (nitrapyrin) rate.

Application Timing	Instinct Rate	Corn Grain Yields 2011	2012	2013	3-yr avg.
	kg ai ha^{-1}	Mg ha^{-1}			
Early Oct.	0.00	10.8	11.0	10.4	10.7
Early Oct.	0.56	11.3	10.7	11.6	11.2
Early Oct.	1.12	11.6	11.3	11.9	11.6
Early Nov.	0.00	11.5	11.8	12.1	11.8
Early Nov.	0.56	12.2	11.4	11.7	11.8
Early Nov.	1.12	12.2	11.6	12.1	12.0
Main effect of application timing					
Early Oct.		11.2b	11.0a	11.5b	11.2b
Early Nov.		11.9a	11.6a	12.0a	11.8a
Main effect of Instinct (nitrapyrin) rate					
0 kg ai ha^{-1}		11.1b	11.4a	11.2b	11.2a
0.56 kg		11.8a	11.0a	11.7ab	11.5a
1.12 kg		11.9a	11.4a	12.0a	11.8a
Interaction of main effects (*P>F*):					
Timing × rate		0.76	0.84	<0.01	0.18

Discussion

- **A warm October in 2010 likely nitrified some N from manure applied in early October (Table 1). Similar conditions occurred in the fall of 2011.**
- **Less than normal rainfall in July, August and September of 2012 increased variability among blocks and reduced yield potential.**
- **A wet spring in 2013 was ideal for N loss due to leaching and denitrification.**
- **Significantly less soil NO_3-N and greater NH_4-N were found when Instinct (nitrapyrin) was added to manure injected in October (Figure 1).**
- **Instinct did not affect soil NO_3-N concentration with November manure application.**
- **These data show Instinct slowed nitrification of swine manure applied in early October with little difference between rates of application.**
- **Corn grain yields were greater than the control with all manure and fertilizer N treatments (Figure 2).**
- **Generally, a November application of swine manure with or without Instinct had similar yields when compared with anhydrous ammonia applied in November.**
- **Delaying application of manure from October to November increased corn grain yields in two of three years and for the three-year average [0.6 Mg ha^{-1} (10 bu ac^{-1})] Table 2.**
- **Adding the nitrification inhibitor Instinct to fall-applied swine manure increased yields in two of three years and three-year average yields trended higher (*P>F* = 0.14).**
- **Yields were increased only with the 1.12 kg ai ha^{-1} rate of Instinct compared with the 0 kg ai ha^{-1} rate in 2013.**
- **These data show Instinct was an effective nitrification inhibitor for liquid swine manure applied in October in southern Minnesota. The 1.12 kg ai ha^{-1} rate was most effective, especially with early fall application. When applied in November, Instinct was less likely to affect corn yields.**

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