When and Where a Nitrification Inhibitor might be Profitable in Corn Production in Iowa

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Background

Nitrification inhibitors are commonly used with fall-applied anhydrous ammonia to increase N-use efficiency and reduce potential yield losses. Because many factors affect the conversion of ammonium to nitrate in the soil, the efficacy and economic performance of commonly used nitrification inhibitors in corn (*Zea mays* L.) production can be extremely variable.

Liquid swine manure contains a considerable amount of ammonia or ammonium-N and the manure is often applied in the fall before the soil temperatures are low enough to substantially retard nitrification. As a result, large N losses of manure are commonly observed from excessive spring rainfalls. To reduce these losses, a nitrification inhibitor might be used with injected liquid swine manure.

The objective was to identify field and within-field level factors at which the use of Instinct™ (an encapsulated form of nitrapyrin) nitrification inhibitor with liquid swine manure can be profitable in Iowa.

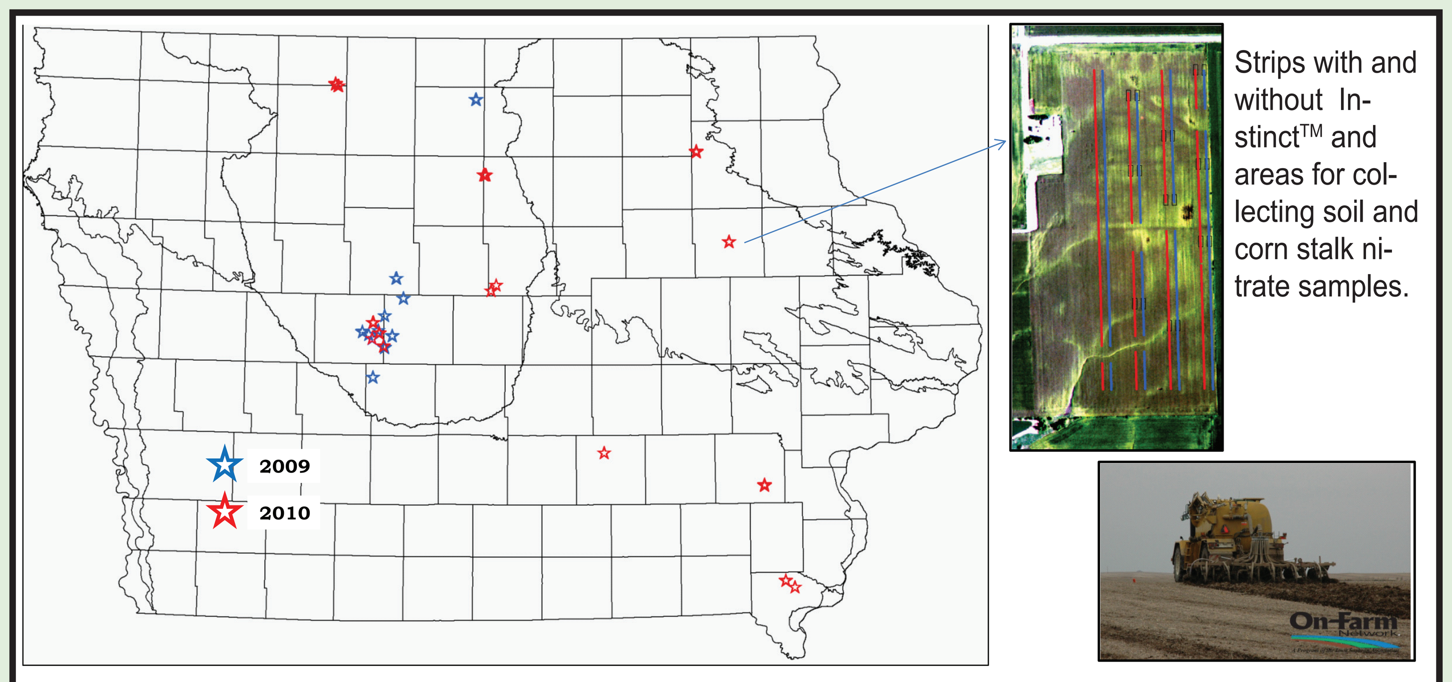

Figure 1. Locations of on-farm strip-trials having injected liquid swine manure applied with and without Instinct™ nitrification inhibitor in 2009 and 2010.

Method and Data Analysis

Instinct™ is an encapsulated form of nitrapyrin. The capsules are designed to protect the inhibitor from volatilization losses, from permanent fixation by soil organic matter or clay minerals and to enable the slow release of the inhibitor with potentially longer inhibition action.

Instinct was evaluated in 11 on-farm trials (Fig. 1) in 2009 and 15 trials in 2010. Each trial had two treatments – injected liquid swine manure with and without Instinct – replicated 3 to 5 times. In each year, all trials were corn after soybean (C-S), except three planted to corn after corn.

Nitrogen status of corn was evaluated by using the late-spring soil nitrate test (only in 2010), the end-of-season corn stalk nitrate test, digital aerial imagery of the corn canopy, and by analyzing distributions of yield responses (YR) estimated for each trial. The YR distributions were derived by partitioning yields into 150 ft. long cells along each pair of the treatments. Stalk and soil nitrate samples were collected at 9 locations within each field (Fig. 1).

Hierarchical statistical analysis was used to simulate predictive YR distributions and to identify potential effects of field-scale factors – monthly and cumulative rainfall – and within-field factors – soil organic matter (SOM), slope or soil drainage class – on YR to the inhibitor.

Analysis of digital aerial imagery was done to identify differences in reflectance of the corn canopy between the two treatments. The green reflectance values were extracted from the area of about half the width of each strip.

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Table 1. Parameters for yield response (YR) distributions# from evaluating Instinct™ nitrification inhibitor with injected liquid swine manure in 2009 and 2010.

	2009	2010
	bu/acre	
Observed pooled mean YR	-0.1	1.9
Distribution parameters		
Mean YR	-0.1	2.3
90 % CI for mean	[-1.8; 1.6]	[0.4; 4]
Between trial SD	2.2	3.2
Within trial SD	9.8	8.2
	2010	
	Spring rainfall	
	<10 in	>10 in
	bu/acre	
Observed pooled mean YR	0.3	8.1
Distribution parameters		
Mean YR	0.6	7.9
90 % CI for mean	[-0.6; 1.9]	[3.7; 13]
Between trial SD	1.4	0.3
Within trial SD	7.2	1.4

#YR distributions were derived by partitioning yields in each strip into 150-feet long cells.

‡ Disributions were simulated using Markov Chain Monte Carlo method with 10,000 runs.

CI; credible intervals.

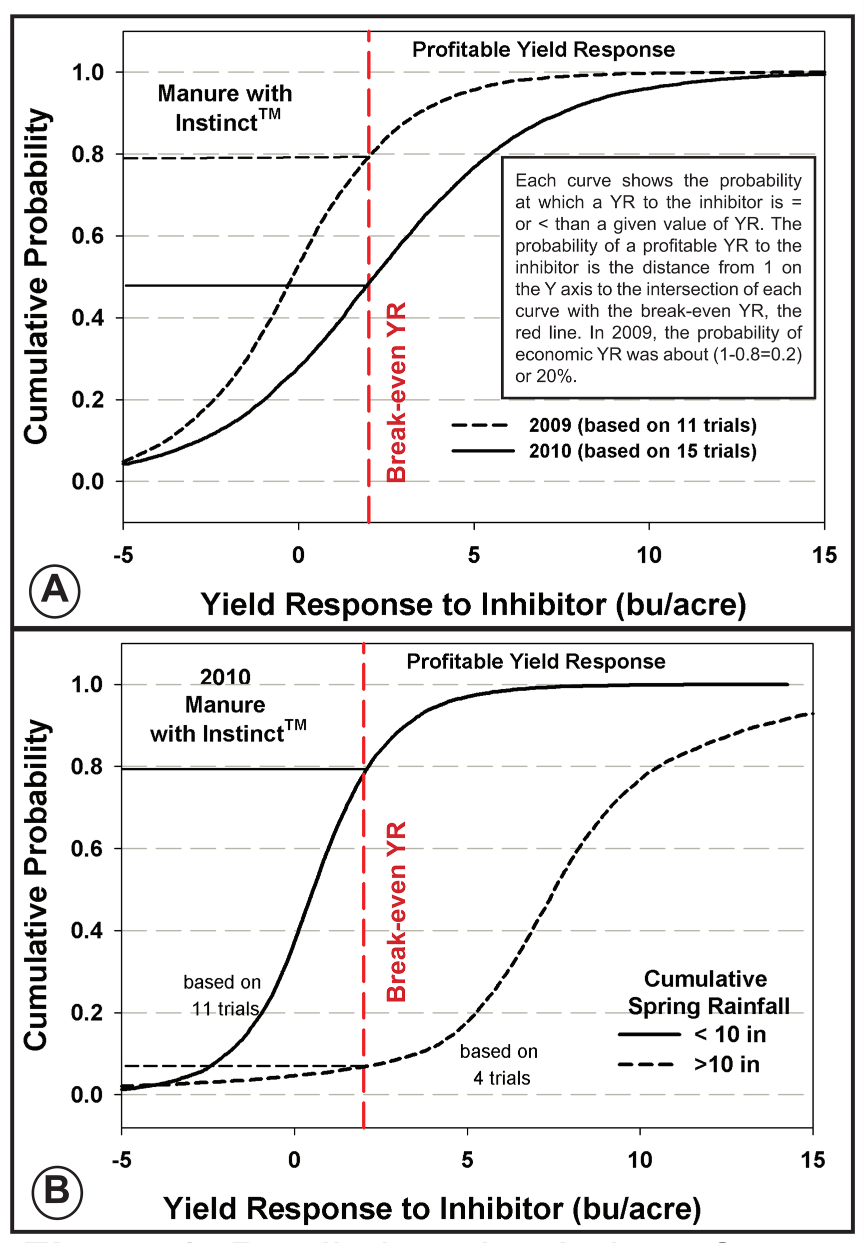

Figure 2. Predictive simulations for field-level mean YR to Inhibitor for unobserved fields.

Results

In both years for C-S, the average N rate applied with manure was about 170 lb. of total N/acre. About 60% of the trials received additional 30 to 50 lb. N/acre to avoid large yield losses after wet spring in 2009 and wet early June in 2010 (Fig. 3).

On average, the inhibitor did not increase yield in relatively normal 2009 but increased yield by 2 bu./acre in relatively wet 2010 (Table 1). In 2010, the 90% confidence interval for the mean YR ranged from 0.4 to 4 bu./acre. Based on field-level simulations for unobserved fields, about 20% of the trials were predicted with a profitable field-level YR in conditions similar to 2009 (Fig. 2A) and about 50% of trials in conditions similar to 2010 (Fig. 2 B).

In both years, within field variability in YR was 3 to 5 times larger than between field variability (Table 1), however, none of the spatial factors – SOM, drainage or slope – had effect on YR. Also, field level factors – total N rate and time of application – did not influence YR.

In 2010, fields with above normal spring rainfall (>10 in.) were predicted to have a field-level profitable YR about 70% more often than those with below normal spring rainfall (Table 1 and Fig. 2B). However, the predicted effects should be studied more because only 4 fields in 2010 (southeastern corner of Iowa, Fig. 1) had excessive spring rainfall.

In both years, the inhibitor did not affect corn N uptake (Fig. 4). However, >50% stalk samples tested deficient in both years, suggesting ideal conditions for detecting YR. Other on-farm trials with the same manure N rates and an extra 50 lb. N/acre produced an average YR of 7 bu./acre in 2009 and of 10 bu./acre in 2010.

In 2010, soil mineral-N measured in early June was not affected by the treatments (Table 2), suggesting that the inhibitor effects may have passed by the time of soil sampling.

On average, the inhibitor decreased the green reflectance of the corn canopy by about 4% compared with the control, partially confirming the observed positive YR in 2010 (Table 2). For both treatments in both years, within strip variability in the corn canopy reflectance was the same.

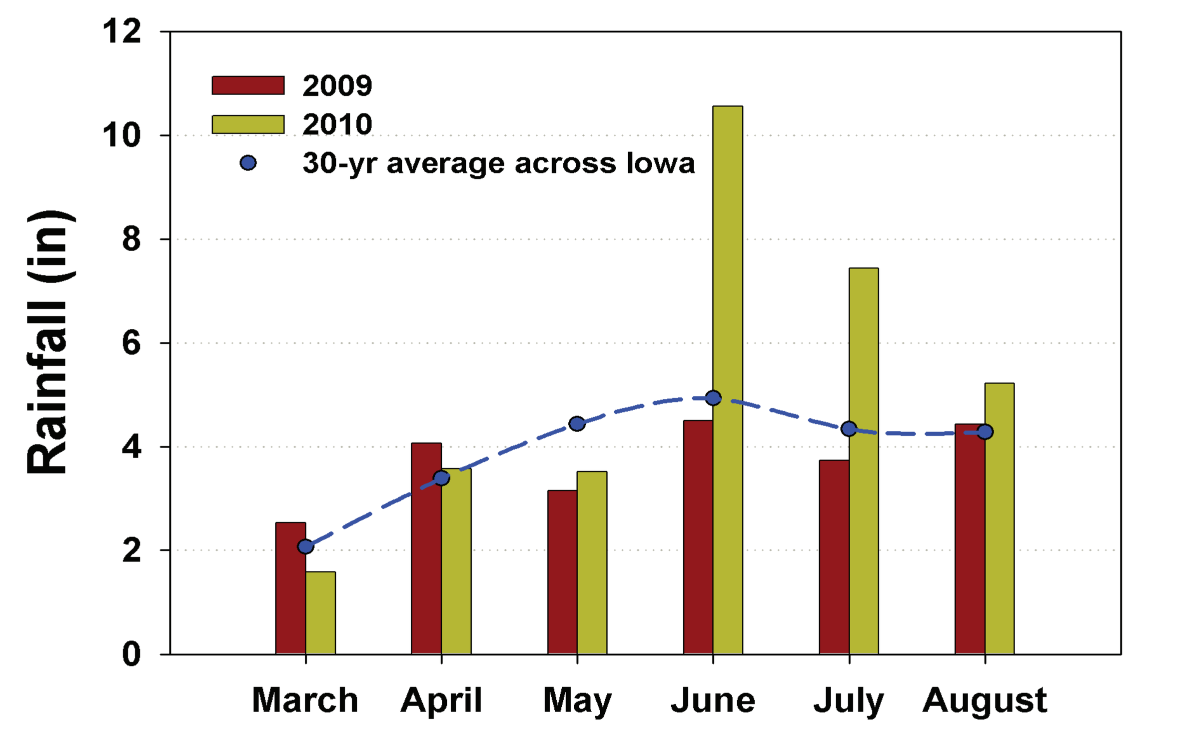

Figure 3. Average monthly rainfall for on-farm trials studied in 2009 and 2010.

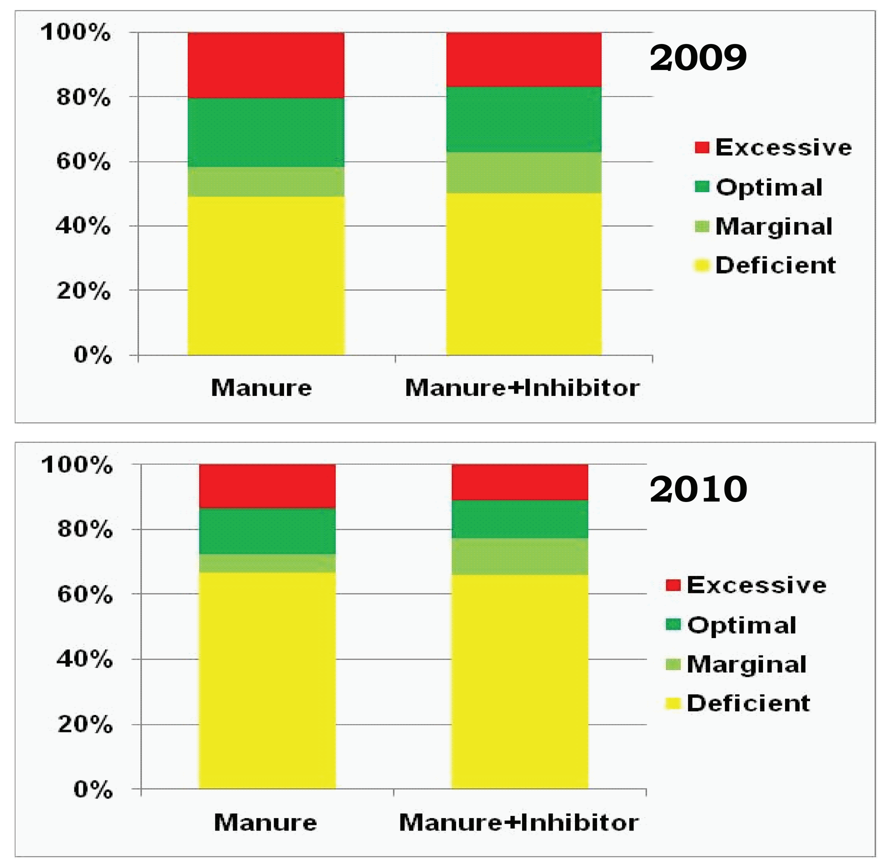

Figure 4. Percentage of stalk samples tested in the four categories of corn N status. In both years for both treatments, geometric means nitrate-N of all trials indicated deficient corn N status.

Table 2. Effect of Inhibitor on soil mineral-N measured in early June of 2010 and on green reflectance of the corn canopy measured in late August of 2009 and 2010.

	Manure	Manure+Inhibitor
	Late Spring Soil Nitrate Test	
2010	ppm	
NH_4-N	5	6
NO_3-N	23	23
Mineral-N	28	29
	Green band reflectance	
2009	108¶ (20)	108 (20)
2010	77** (21)	73 (21)

Measured within the top 30-cm of the soil layer at 9 locations.

¶ Mean and SD for the green band reflectance.

** Statistically different based on 14-paired comparisons of trial-level mean reflectance values.

Conclusions

In the relatively normal year (2009), Instinct™ had no effect on yield or corn N uptake.

In the relatively wet year (2010), the inhibitor produced: 1) a positive YR, with 50 % chance of profitable YR; 2) slightly decreased the green reflectance of the corn canopy; 3) but did not increase soil mineral N nor late-season corn N uptake.

In 2010, fields with above-normal spring rainfall (>10 in.) were 70% more likely to have profitable YR than those with below normal spring rainfall.

In both years, the majority of the fields had deficient corn N status for treatments with and without the inhibitor.

The inhibitor effect may have rapidly diminished during winter or early spring, suggesting the low likelihood of economic benefits from its use for all fields receiving injected liquid swine manure in Iowa.