UREA APPLICATION TIMING INFLUENCE ON NO-TILL CORN

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Abstract

Fertilizer N for no-till corn in South Dakota is often limited to surface applications of urea. Surface applied urea can volatilize. A study was conducted in 1998, 1999, 2000 and 2002 (four site years) on no-till corn comparing surface broadcast urea timing. Nitrogen rates (50 and 100 lbs N/a) were applied in the fall, winter, early spring, planting, and V-6 stage. Ear leaf samples were analyzed for N concentration in 1999 and 2000 and grain yield was measured each year. Precipitation was measured at gauges within 2 miles of each site and compared to long term means. Precipitation for N timings was summarized as days: 1) after application to first precipitation event, 2) to accumulation of 0.25 inches, 3) to first precipitation event of at least 0.25 inches. Ear leaf N was increased significantly with increasing N rate but not changed by N timing. Grain yield increase was statistically significant for increasing N rate and timing. Nitrogen applied at planting and V-6 had significantly higher yields when compared to N applied in the fall, winter, or early spring. The precipitation summary showed fall and winter N applications were on the surface for more days on average without significant precipitation. Excessive precipitation was not received at these sites and therefore reduced the possibility of nitrate leaching. While this study does not quantify N volatilization, it is clear more N was lost from applications made in late fall and winter than from those made at planting.

Introduction

Surface urea nitrogen applications in no-till are relatively inexpensive and easy to accomplish but are subject to volatilization losses under certain conditions. Sub-surface nitrogen application limits volatilization losses but application options in no-till corn production are limited and cause soil disturbance. Anhydrous ammonia application requires more power, time, and safety precautions than broadcast urea N. Application of UAN (28-0-0) requires more equipment and material costs are generally higher than with dry fertilizer use. Urea volatilization losses can vary greatly depending on numerous factors; however, some management practices such as timing of application can minimize losses.

Literature Review

The rate of conversion of urea to ammonium is slowed as temperatures decrease due to reduced urease activity. Several researchers have compared N materials and application methods on yield for no-till corn, but with only one application timing. Similar treatments from these studies were summarized by N sources (Table 1). Comparison of N sources on corn yield show ammonium nitrate had the highest yield followed by urea ammonium nitrate and then urea. The authors attributed the yield differences to losses of N from volatilization.

A summary of studies using broadcast urea, broadcast UAN and injected UAN after planting show UAN injected resulted in the highest yield followed by UAN broadcast and broadcast urea (Table 2). Again, the authors attributed the yield differences to losses of N from volatilization.

The studies in these comparisons were all conducted in areas that have much higher rainfall, humidity, and temperatures than South Dakota. These conditions may contribute to higher N volatilization from urea. Therefore, a research project was conducted in South Dakota during 1998, 1999, 2000, and 2002 to evaluate surface applied urea N application timing effects on no-till corn grain yield.

Table 1. A 28 site year summary of mean no-till grain yield as influenced by N source.

N source applied on soil surface after planting.	Grain Yield bu/a
Urea	124
Urea Ammonium Nitrate	128
Ammonium Nitrate	140

Adapted from Bandel, et al. 1992, Fox and Hoffman, 1981, Stecker et al. 1993, Howard and Essington, 1998, Varsa, et al. 1998

Table 2. A 19 site year summary of mean no-till corn grain yield as influenced by N source and application method.

N source and method applied after planting.	Grain Yield bu/a
Urea broadcast	121
Urea Ammonium Nitrate broadcast	126
Urea Ammonium Nitrate injected	147

Adapted from Mengel, et al. 1982, Howard and Essington, 1998, Varsa, et al. 1998

Materials and Methods

Urea was broadcast on the surface on an established no-till site each year for four years in a corn and soybean rotation in Eastern South Dakota. The timing of urea application was fall (November), winter (January), early spring (March), planting (May), and V-6 growth stage (June). The mean application dates were November 11, January 6, March 11, May 1 and June 15. The January application was timed to avoid significant snow cover and the March application was after any permanent snow cleared. The November application was made when soil temperatures neared freezing on the surface.

Nitrogen rates applied were 50 and 100 pounds per acre. A zero N check treatment was also maintained. The plot design was randomized complete black split plot with four replications. The main plot was application timing treatment and the split plot was nitrogen rate. Plot size ranged from 400 to 750 square feet over the four-year study period.

Precipitation was measured within two miles of each site. For each mean date of nitrogen application timing, the following three precipitation event parameters were calculated; 1) mean number of days to first precipitation event 2) mean number of days to accumulation of 0.25 inches and 3) mean number of days to precipitation event of at least 0.25 inches. Ear leaf samples were taken at silking for total nitrogen concentration. A plot combine was used each year to harvest the center two rows of each plot.

Soil samples were taken prior to fall nitrogen application from 0-6 and 6-24 in depths and analyzed for nitrate, organic matter, phosphorus, potassium and pH (Table 3). Carry over soil nitrate N levels ranged from 20 to 52 pounds per acre and were typical of those found in nitrogen responsive fields. Soil pH was considered optimal for corn production and not excessively high which can increase volatilization. Available phosphorus levels (Table 3) were adequate for corn except for the 1999 site (Gerwing and Gelderman 2001). At this site phosphorus was both broadcast and applied in the starter. Soil test potassium was considered adequate and no additional potassium was applied.

Table 3. Soil tests for the N application timing study for no-till corn in South Dakota.

	Soil Test Parameter				
Project Year	Organic Matter[1]	K[1]	pH[1]	Olsen P[1]	NO_3-N[2]
	%	ppm		ppm	lbs/a
1998	3.3	203	6.6	23	31
1999	3.8	184	5.7	5	20
2000	3.3	159	7.2	19	52
2002	3.3	143	6.7	13	44

[1] soil sample depth = 0-6 inches
[2] soil sample depth = 0-24 inches

Results and Discussion

Ear leaf N concentration was increased significantly by increasing N rate (Table 4 and Figure 1). Nitrogen timing did not have a significant effect on ear leaf N concentration at either N rate (Table 4). However, ear leaf N concentration was highest with N application made later in the growing season and closely resembled the grain yield response to N application timing and rate (Figure 2).

Table 4. ANOVA for ear leaf N concentration and grain yield for the N application timing study on no-till corn in South Dakota.

Source of Variation	Ear Leaf N Concentration	Grain Yield
	--------------- Pr > F	---------------
Rep	0.376	0.003
Site Year	0.532	0.001
N timing	0.205	0.036
N rate	0.002	0.002
Year * N rate	0.018	0.186
Year * N timing	0.006	0.868
N timing * N rate	0.316	0.459
By N rate:		
50 lbs N/a		
Rep	0.706	0.799
N timing	0.284	0.177
100 lbs N/a		
Rep	0.980	0.629
N timing	0.629	0.359

N application timing and rate significantly influenced grain yield (Tables 4 and 5). Grain yield was highest with the V-6 and planting applications of nitrogen. The fall and winter N application timings had the lowest grain yield while the early spring application was not significantly different from either the highest or lowest grain yield group. Grain yield increased with N rate (Figure 2).

Precipitation for April through June in 1998 and 2002 was more than 2.5 inches below normal and for 1999 and 2000 it was less than 2 inches above normal (Table 6). Excessive rainfall was not received in any of the study years and therefore nitrate leaching was probably minimal.

Table 5. Influence of surface urea application timing on no-till corn in South Dakota.

Urea Timing	Grain Yield[1]
	bu/a
Fall	98 b
Winter	98 b
Early Spring	103 ab
Planting	106 a
V-6	107 a
LSD (.05)	6.5

[1]mean of four site years

Table 6. April through June precipitation for the no-till corn N application timing studies in South Dakota.

	Year			
Precipitation	1998	1999	2000	2002
Measured[1]	4.83	10.59	11.01	6.4
Long-term mean[1]	9.02	8.59	9.02	9.02
Mean departure	-4.19	1.64	1.99	-2.62

[1] April through June

If urea remains on the soil surface and little or no precipitation is received to move it into the soil, it is subject to volatilization loss. Two other major factors that contribute to urea volatilization are soil pH and temperature. It has been shown in the past that as temperatures cool, urea volatilization is reduced. Rawluk et al. (2001) measured between 1 and 2 lbs N/a/day volatilized at temperatures between 45 and 50 degrees Fahrenheit. Therefore if conditions remain dry for long periods, significant volatilization could occur even at cool temperatures.

At these study sites, on the average, 10-14 days passed after the fall and winter applications before the first precipitation events, and the events were less than 0.10 inches (Table 7). It took over 50 days to accumulate 0.25 inches and over 70 days before a precipitation event greater than 0.25 inches occurred. For the early spring urea application it took 18 days to accumulate 0.25 inches and 25 days until a 0.25 inch precipitation event occurred. However, for planting and V-6 urea applications, it took only 5-9 days to accumulate 0.25 inches of precipitation and merely 6-10 days for a 0.25 inch precipitation event to occur. The less time to a significant precipitation event could have minimized volatilization loss. It appears that even though the volatilization rate of loss may be slow in the fall and winter when temperatures are cool, the accumulated loss before significant rainfall is larger than losses in the spring when temperatures and volatilization rates may be higher but rainfall is more frequent.

Table 7. Mean urea application timing and precipitation influence on no-till corn grain yield in South Dakota during 1998, 1999, 2000, and 2002.

Urea Timing	Date applied	Grain Yield[1]	First Precipitation Event: After N applied	First Precipitation Event: Amount	Days to Precipitation: 0.25 inches total	Days to Precipitation: 0.25 inch event
		bu/a	days	inches	days	days
Fall	Nov. 11	98 b	10	1.05	56	90
Winter	Jan. 6	98 b	14	0.08	53	72
Early Sp	Mar. 11	103ab	6	0.12	18	25
Planting	May 1	106 a	7	0.75	9	10
V-6	June 15	107 a	3	0.49	5	6

[1] 4 year mean, 50 and 100 lbs N/a, LSD(.05)=6.5

Conclusions

1) Higher no-till corn yields were associated with surface applied urea in spring compared to late fall and winter.

2) Volatilization losses of nitrogen from surface applied urea are suspected in the lower corn yields resulting from earlier applied treatments.

3) Length of time to the first significant precipitation could have contributed to the suspected volatilization loss.

4) Incorporation or injection of urea materials or application before a major precipitation event are possible solutions to the problem.

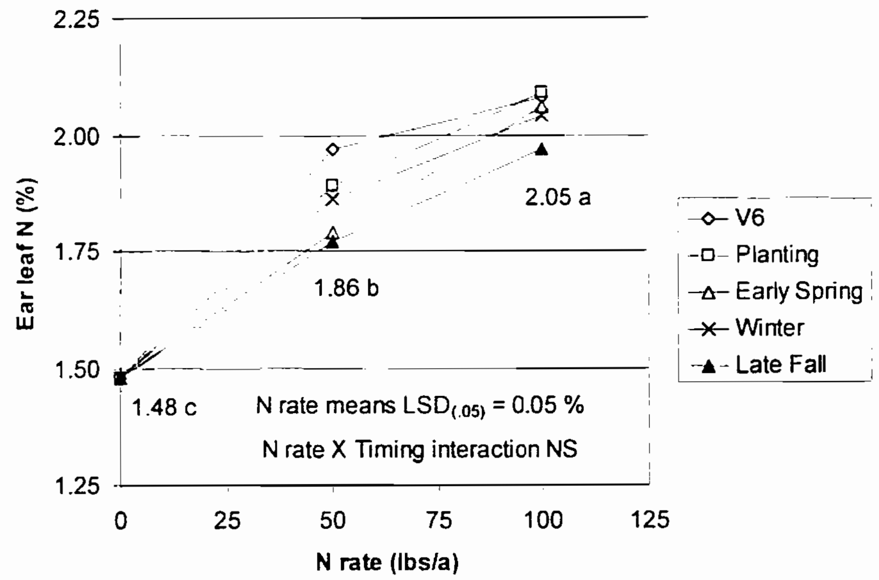

Figure 1. No-till corn ear leaf N concentration response to N rate and application timing of surface applied urea (mean of 1999 and 2000).

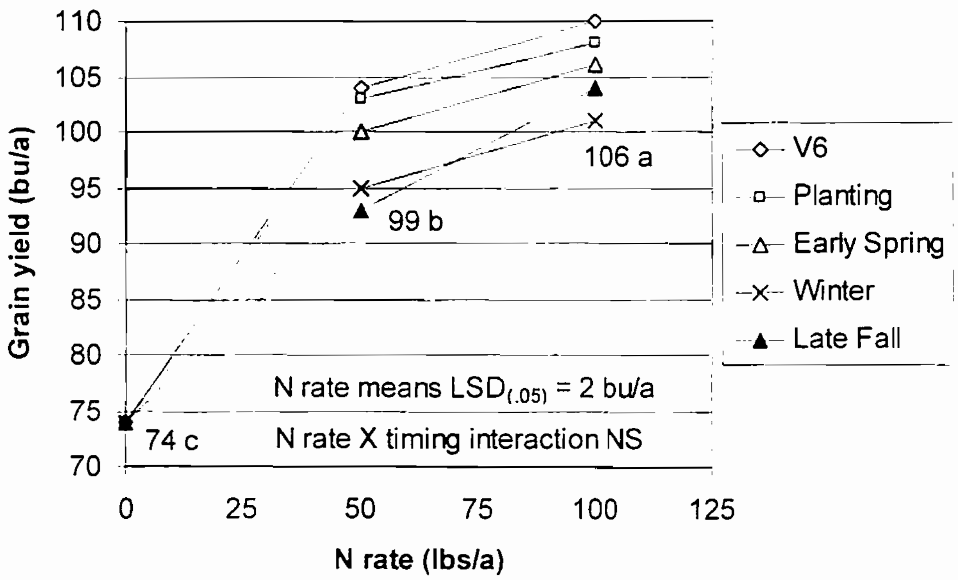

Figure 2. No-till corn grain yield response to N rate and application timing of surface applied urea (mean of 1998, 1999, 2000 and 2002).

Acknowledgments

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