UW Extension Ashland/Bayfield County
Research Bulletin
No. 24
Date: Nov 2012

Fertilizing Corn with Protected Nitrogen

Jason Fischbach, UW-Extension Agriculture Agent
jason.fischbach@ces.uwex.edu

Introduction

Corn silage is an important crop for dairy producers in the Lake Superior Counties of Wisconsin and there is growing interest in corn grain production as grain prices rise and short-season hybrids become more productive. The short growing season and challenging soils of the region leave little room for error. Thus, it is important that factors that can be controlled, such as nitrogen fertilization, be optimized.

Nitrogen is available to plants as either ammonium or nitrate. Producers in the region generally rely on ammonium from manure applications and/or urea applied at planting. Urease rapidly converts urea to ammonia gas. The gas is rapidly lost to the atmosphere (volatilized) unless it reacts with water to form ammonium. Thus, urea should either be protected, applied immediately prior to rain, or incorporated. Once soil temperatures exceed 50 F, the ammonium is converted into nitrates, which are susceptible to loss from leaching and/or denitrification. Leaching losses are likely to be highest on the sandy soils where water moves through the soil profile more rapidly. On the heavier clay soils, nitrate losses are more likely to come from denitrification caused by saturated or compacted soils.

In cooperation with area producers, UW-Extension has been conducting nitrogen trials to evaluate protected nitrogen options and determine optimum nitrogen fertilization strategies. A nitrogen rate validation trial in 2010 at three locations found that 120 lbs actual N is sufficient for corn production in the region and that crediting nitrogen from manure and legume sources along with the pre-sidedress-nitrate test would help producers avoid over-application of nitrogen, particularly broadcast applications of urea at planting or after emergence (Fischbach, 2010).

Protected nitrogen is likely to increase availability of nitrogen longer into the season and possibly increase yields, particularly in wet years where the nitrates are likely to leach on sandy soils or be denitrified in saturated clay soils. In 2011, a trial conducted at three locations found that splitting applications of urea had no significant impact on corn yields, however, the use of ESN tended to increase yields on sandy soils but not clay soils (Fischbach, 2011).

In this trial, we compared the yield response of corn to split applications of urea with or without Agrotain™ or ESN. The Agrotain™ inhibits the urease enzyme and protects the urea until it reacts with water to form ammonium. A yield response to Agrotain would be most likely with unincorporated urea followed by warm and dry conditions. ESN is an encapsulated urea that is protected by the polymer coats until warm temperatures and moisture move the nitrogen into the soil solution for uptake by plants.

Methods

Table 1 shows the details for each of the two trial locations. Location 1 was established on an Annalake fine sandy loam (517C). The previous crop was soybeans. Ammonium sulfate was broadcast prior to planting at a rate of 75 lbs/ac. The corn was no-till seeded on May 20 with 20" row spacing. The nitrogen treatments were applied on May 23 by broadcasting the nitrogen fertilizer to each plot by hand. For the split application treatments, the second application was made on June 16. Location 2 was established on a Port Wing clay loam (480B). The previous crop was corn silage.

The corn was seeded with 20" row spacing on May 25. No supplemental nitrogen was applied. The treatments were applied prior to planting on May 23 by broadcasting the nitrogen fertilizer to each plot by hand. Split applications were made on July 2. The trial was designed as a randomized complete block with three replications of each of five treatments listed in Tables 2 and 3. Each plot was 20' long and 10 rows wide. Total nitrogen applied for each treatment was 120 lbs actual N per acre. At Location 1 total applied nitrogen for each plot was 175.75 lbs/ac (40 lbs soybean N credit + 15.75 lbs AMS + 120 lbs treatments). At Location 2, there was no legume credit or applied supplemental N.

Table 1. Details of Each of The Two Trial Locations

	Location 1	Location 2
Soil Type	Annalake 517C fine sandy loam	Port Wing 480B clay loam
2011 Crop	Soybeans	Corn
Planting Date	20-May	25-May
Row Spacing	20"	20"
Site Prep	no-till	disk, harrow
Supplemental N Fertilizer	75 lbs AMS, broadcast April 20	None
Weed Control	glyphosate	glyphosate
Actual plants/acre	30,855	29,112
Silage Harvest	11-Sep	11-Sep
Grain Harvest	14-Sep	15-Oct

To determine total biomass yield all plants within a 12' x 2 row quadrant from the center of each plot were harvested and weighed. A four stalk sub-sample pulled at random from the harvested quadrant was immediately chopped, weighed, and dried to determine dry matter. To determine grain yield, the total number of ears were counted in each row immediately adjacent to the harvested biomass quadrant (number of ears per 24' of row). Eight ears were harvested from the two rows immediately adjacent to the harvested quadrant and husked. These 8 ears were chosen by harvesting every fourth ear in each of the adjacent rows. The ears were husked and weighed. Three ears were then chosen at random, weighed, and all kernels were removed to determine shelling percentage by weight. A sub-sample of the shelled kernels were then dried to determine moisture content. Plot grain yield was converted to a 15.5% moisture and extrapolated to a per acre basis. Analysis of variance was conducted with a 0.10 significance level and Fishers Least Significant Difference test was used to separate means. Treatment means would have to differ by more than the LSD value to be considered statistically significant at the 0.10 level.

Results

Table 2 shows the silage yield in response to each treatment at each of the two locations. At Location 1 there was no statistically significant difference in silage yield across the treatments. The same was true at Location 2. However, at Location 1 there was a trend toward a positive yield response from substituting half of the urea with ESN.

Table 2. Corn silage yield (9/11 harvest) in tons/ac at two locations in response to different nitrogen applications.

	Location 1		Location 2	
Treatment	**DM**	**65%**	**DM**	**65%**
	----------------------------tons/ac---------------------			
260 lbs urea at planting	8.4	23.9	5.6	16.1
130 lbs Urea+130 lbs ESN at planting	9.0	25.8	6.2	17.7
130 lbs urea at planting and 4 wks	8.0	22.9	5.9	16.9
260 lbs urea w/Agrotain at planting	8.0	22.7	5.9	16.7
130 lbs urea /w Agrotain at planting and 4 wks	8.0	22.8	6.3	18.1
P-Value	0.736		0.677	
LSD(0.05)	**2.0**	**5.7**	**1.1**	**3.1**

Table 3 shows the grain yield in response to each treatment at the two locations. At Location 1 there was no yield response to using Agrotain protected urea compared to urea alone when applying all the urea at planting. Interestingly, though not statistically significant, using Agrotain when splitting urea applications tended to decrease grain yields. Substituting half of the urea with ESN at planting had no apparent yield advantage to using all unprotected urea. At Location 2, though not statistically significant, using Agrotain treated urea when applying split applications tended to increase grain yields compared to urea alone, but there was no apparent yield increase from Agrotain when all the urea was applied at planting. The substitution of urea with ESN tended to decrease grain yields compared to urea alone, though the difference was not statistically significant.

Discussion

Providing sufficient nitrogen fertilizer for corn production without losing nitrogen to leaching or volatilization is a major challenge. Incorporating nitrogen, splitting nitrogen applications in time, using multiple nitrogen sources, or using protected urea are all strategies to optimize applied nitrogen. In this study, splitting urea into two applications had no apparent effect on silage production at either the sandy loam or clay loam locations. Interestingly, splitting the urea into two applications tended to increase grain yield at the sandy loam site but decrease grain yield at the clay loam site, though not at the 0.10 significance level. This does suggest that split applications may compensate for leaching losses on the sandy soils, and, possibly, limit early-season nitrogen availability in the clay soils due to slower conversion of urea to nitrates.

Table 3. Corn grain yield in bu/ac at two locations in response to different nitrogen applications.

	Location 1		Location 2	
Treatment	**DM**	**15.5%**	**DM**	**15.5%**
	----------------------------bu/ac---------------------			
260 lbs urea at planting	181	215	119	141
130 lbs Urea+130 lbs ESN at planting	185	219	104	123
130 lbs urea at planting and 4 wks	193	228	107	127
260 lbs urea w/Agrotain at planting	185	219	115	136
130 lbs urea /w Agrotain at planting and 4 wks	173	204	120	142
P-Value	0.929		0.728	
LSD(0.05)	**51**	**61**	**32**	**37**

Replacing a portion of the urea applied at planting with the "slow-release" ESN can possibly mimic a split application. This is important particularly with 20" row spacing where a later entry into the fields may not be feasible. At the sandy loam site, ESN tended to increase silage yield, but had no apparent affect on grain yield. At the clay loam site, ESN may have slightly increased silage yield, but tended to reduce grain yield. These results are consistent with earlier work that found that ESN tended to increase yields on sandy soils, but had no effect on clay soils (Fischbach, 2011). Functionally, the ESN may be preferable to other forms of protected nitrogen as it slows the release of the nitrogen and thereby protects it from volatilization, leaching, and denitrification. However, on clay soils that take longer to warm up, limiting early season nitrogen could limit yields. Additional work to correlate soil nitrate, temperature, and applied nitrogen would be necessary to better understand the fate of ESN nitrogen and its effect on corn production.

The use of Agrotain to protect the urea from conversion from ammonium to ammonia and, therefore, reduce volatilization had no apparent affect on silage yield at either location. There was also no clear grain yield increase from Agrotain when applying all the urea at planting. This is likely due to significant rainfall shortly after application at Location 1 and incorporation at Location 2. Using Agrotain with split applications may have had an impact on grain yields. At Location 1, the Agrotain may have reduced yields, but at Location 2 the Agrotain may have increased yields. A slight increase in grain yields is not surprising on the clay soils, particularly because the second urea application at Location 2 occurred in early-July during the hottest time of the year when volatilization losses would be highest. The yield decrease observed at Location 1 is surprising as Agrotain shouldn't reduce nitrogen availability, particularly in a late-season application. Why this occurred is unknown.

Conclusions

Nitrogen fertilization trials completed in the last few years in Ashland and Bayfield County suggest the following nitrogen optimization strategy for corn:

1. Properly credit nitrogen availability from legume and manure sources.
2. Total available nitrogen beyond 120 lbs/ac is unlikely to increase yields.
3. A pre-sidedress nitrate test should be used to determine whether a post-emergence application of nitrogen is necessary.
4. The benefits of Agrotain or ESN have not been clearly demonstrated in two years of trials, however, replacing some urea with ESN may increase yields on sandy soils.

The use of ESN warrants additional investigation in the region particularly when split applications aren't possible due to soil conditions or the use of 20" rows. This form of protected nitrogen may be the most sensible as it defends against the full range of losses likely to occur in the region. ESN trials will be implemented in 2013 to better determine corn yield response to a range of ESN application rates.

Acknowledgements

Thanks to Morgan Peck, and Brian Anderson for their assistance with these trials. Thanks also to United Ag Services for providing the urea and ESN. Thanks to Phil Holman for assistance chopping and drying silage samples.

Comments and questions should be directed to Jason Fischbach at 715-373-6104 ext 5 or jason.fischbach@ces.uwex.edu.