
EVALUATION OF NEW NITROGEN FERTILIZER TECHNOLOGIES FOR CORN

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INTRODUCTION

Farmers today are faced with escalating fertilizer prices, especially for nitrogen. In addition, new state and federal regulations are reducing the availability of some products such as anhydrous ammonia and ammonium nitrate. It appears that urea is going to be the primary replacement for these products. But urea requires a higher level of management to prevent N losses and inefficient N use.

The current nitrogen recommendation numbers for corn in Illinois range from 0.8 to 1.2 lb N/bu based on yield goal, previous crop, manure credits and other incidentals. But corn has a nitrogen use efficiency (NUE) of less than 50% on average. Fertilizer N losses can occur from leaching, volatilization, denitrification, and immobilization. Several new N technologies have recently appeared on the market in Illinois to reduce N loss potentials. Many of these products are being evaluated in this study.

The objectives of this study are to 1) evaluate the effects of new nitrogen fertilizer technologies on corn yields under conventional tillage for corn after corn systems, 2) use buried "teabags" to trace N release curves from slow release N products, and 3) determine the N use efficiencies for new nitrogen fertilizer technologies.

MATERIALS AND METHODS

Nine different N sources were utilized at five locations across the state of Illinois. These sources included 1) liquid urea-ammonium nitrate (UAN) sidedress injected, 2) urea surface broadcast, 3) UAN surface broadcast, 4) urea + agrotain® (Agrotain International) surface broadcast, 5) UAN + agrotain surface broadcast, 6) UAN + agrotainplus® (agrotain plus a nitrification inhibitor, Agrotain Intl.) surface broadcast, 7) UAN + 10% v/v CaTs® (calcium thiosulfate, Tessenderlo Kerley) surface broadcast, 8) SuperU® (urea with agrotain and a nitrification inhibitor, Agrotain Intl.) surface broadcast, and 9) ESN® (a polymer coated urea, Agrium US, Inc.) surface broadcast. All of the above treatments were applied at planting, except for the sidedress UAN injected treatment. Treatments also included each of the N sources above either incorporated into the soil with a final tillage pass (disk or field cultivator) or left on the surface. There were also four nitrogen rates associated with each of the above N source/ placement

treatments, plus a check plot which received no fertilizer N. The nitrogen rates used were 60, 120, 180 and 240 lb N/acre.

The four locations are listed in Table 1 below along with soil type, drainage class and fertilizer application dates associated with each location. The Dixon Springs (DSAC) and Belleville sites includes both conventional tillage (CT) and no-tillage (NT) systems, but fertilizer sources did not include incorporation with the NT system. The NT sites also included UAN plus agrotainDF (UAN+AgroDF). With NT, all of the UAN treatments were applied dribbled on 30" spacings.

Table 1. Site information for each location, 2008.

	DeKalb	Urbana	Belleville-CT
Soil Type	Catlin sil.	Flanagan sil.	Caseyville sil.
Drainage Class	Moderately well	Somewhat poorly	Somewhat poorly
Fertilizer Applied	May 21,22	May 29	June 12
Sidedress Date	June 24	Missed	July 10
	Belleville-NT	DSAC-CT	DSAC-NT
Soil Type	Bethalto sil.	Sharon sil.	Grantsburg sil.
Drainage Class	Somewhat poorly	Moderately well	Moderately well
Fertilizer Applied	June 12	June 2	May 16
Sidedress Date	July 10	June 18	June 16

RESULTS AND DISCUSSION

In 2006 (see Ebelhar, et al., 2007), the yield responses associated with N sources could be broken into wet locations (those with >12" rainfall over the 15 week period after fertilizer application) and dry locations (<12"). In 2008, Urbana and DeKalb locations were "wet" and Belleville reached "wet" conditions late in the season (Figure 1). The DSAC CT and NT fields would have been "dry" under this scenario. All of the locations were planted later than usual due to wet weather early in the growing season.

Conventional Tillage Results. Nitrogen source effects were highly significant at the wet locations in 2008 of DeKalb and Urbana (Table 2). They were also slightly significant at Dixon Springs. At Dixon Springs, ESN had a slight advantage (trend only) over the other treatments when incorporated, and the urea treatments had a slight advantage over the UAN treatments (Figure 2). At Belleville, the sidedress treatment tended to be lower yielding, probably due to the treatments being applied relatively late for sidedressing (Figure 3). At Urbana, the sidedress treatments could not be applied due to logistical problems. The dry products tended to do better

than the liquid products, a phenomena seen frequently in the past years of study at several locations. The liquid is UAN based which has 25% of the material as nitrate which is easily leached or denitrified and can be lost quickly from the system. The dry base is urea which has to be converted to nitrate before it can be lost by leaching or denitrification. ESN did much better at Urbana when incorporated rather than left on the surface. This indicates that ESN may have been less available at this location when left on the surface. This may be due to dry weather not letting ESN release it's urea as quickly or ESN was moved offsite by heavy rains. There was a fair amount of N loss from surface applied urea or UAN, indicating volatilization losses, which was reduced significantly by the application of agrotain or superU. The exception was with the application of agrotainplus, but why is uncertain. At DeKalb, the incorporated treatments did better in general than the surface treatments (Figure 5). As with Urbana, the dry products did better than the liquids and the surface ESN treatments did worse than the incorporated.

Increasing nitrogen rates significantly increased grain yields at all locations (Table 3). All of the locations had high check yields (93-101 bu/acre, 39-62% of highest yields).

No-tillage Results. Although Dixon Springs and Belleville had lower rainfall than normal after N application, these sites had much higher than normal rainfall prior to N application which caused problems with planting at optimal timing. At both locations, heavy losses of urea occurred from the surface applications (Table 4 and Figure 6). Products containing agrotain tended to significantly reduce these N losses, presumably from volatilization. Sidedressing injection of UAN or application of ESN also significantly reduced N losses and increased yields. UAN sources had less loss of N than urea.

Because all of the locations and tillage fields had significant quadratic responses to increasing N rates, economic optimum N rates, yields, and nitrogen use efficiencies (NUE, defined as lb N/bu yield) can be determined. In general the dry materials (urea based) had significantly lower NUE than liquids (UAN based, Table 5) with CT fields. With NT, the urea only treatment had a poor NUE, but the other dry treatments had significantly lower NUE than urea or the liquid sources.

CONCLUSIONS

It appears that many of the N sources in this study may provide significant improvements in N use efficiency, especially during wet years. These differences appear to more important with NT than CT systems, but more research is needed.

REFERENCES

Ebelhar, S. A., C. D. Hart, J. D. Hernandez, L. E. Paul, and J. J. Warren. 2007. Evaluation of new nitrogen fertilizer technologies for corn. In E. D. Nafziger (Ed.) 2007 Illinois Fertilizer Conf. Proc., pp 64-71.

Table 2. Effects of N source and incorporation on CT corn yields at each location, 2008.

N Source	DeKalb		Urbana		Belleville		DSAC		Average	
	Incorp.	Surf.	Incorp.	Surf.	Incorp.	Surf.	Incorp.	Surf.	Incorp.	Surf.
----- Corn Grain Yields (bu/acre) -----										
UAN Side Injected	173.9	173.9	n/a	n/a	155.0	155.0	187.9	187.9	n/a	n/a
Urea Broadcast	188.2	188.5	142.5	137.6	161.8	170.6	192.9	186.5	171.4	170.8
Urea+Agrotain	187.6	187.1	139.5	143.2	167.3	164.5	196.5	195.4	172.7	172.6
ESN Broadcast	189.0	177.0	144.4	136.7	166.9	163.6	200.7	193.7	175.2	167.7
SuperU Broadcast	187.9	186.6	140.9	143.5	172.3	165.6	193.7	194.4	173.7	172.5
UAN Broadcast	180.1	169.0	135.1	130.1	161.3	170.6	191.5	188.4	167.0	164.5
UAN+Agrotain	179.9	175.6	133.6	143.9	173.7	169.8	187.0	188.0	168.6	169.3
UAN+AgrotainPlu	175.4	175.5	134.4	129.5	165.2	167.0	188.4	191.6	165.8	165.9
s UAN+CaTs	175.5	170.0	134.7	128.9	165.6	173.3	193.1	187.8	167.2	165.0
Average	181.9 a	178.1 b	138.1	136.7	165.5	166.7	192.4	190.4	168.0	166.6
LSD _{0.05} N Source	10.0		7.3		8.8		7.1			
Statistics:										
N Source (NS)	***		***		NS		*			
N Rate (NR)	***		***		***		***			
Incorporate (IC)	*		NS		NS		NS			
NS x NR	NS		NS		NS		NS			
NS x IC	NS		NS		NS		NS			
NR x IC	NS		NS		NS		NS			
NS x NR x IC	NS		NS		NS		NS			
Sidedress vs Others	NS		n/a		NS		NS			

*, **, and *** refer to significance at the 10, 5 and 1% levels, respectively. NS = nonsignificant.

Table 3. Effects of N rates on corn yields at each location, 2008.

N Rate	DeKalb		Urbana		Belleville		DSAC		Average	
	Incorp.	Surf.	Incorp.	Surf.	Incorp.	Surf.	Incorp.	Surf.	Incorp.	Surf.
----- <i>Corn Grain Yields (bu/acre)</i> -----										
0	93.0	93.0	95.7	95.7	98.1	98.1	100.7	100.7	96.9	96.9
60	156.0	150.8	116.8	118.4	159.4	158.7	173.9	177.8	151.5	151.4
120	200.9	195.4	143.7	137.7	182.8	186.7	214.5	209.9	185.5	182.4
180	223.5	216.1	150.9	148.1	190.4	193.3	235.7	228.0	200.1	196.4
240	236.2	235.3	154.9	155.7	196.4	196.5	237.3	235.6	206.2	205.8
Check (% of Max.)	39%	40%	62%	61%	50%	50%	42%	43%	47%	47%
Statistics:										
<i>NR linear</i>	***		***		***		***		***	
<i>NR quadratic</i>	***		***		***		***		***	

*, **, and *** refer to significance at the 10, 5 and 1% levels, respectively. NS = nonsignificant.

Table 4. Effects of N source and N rate on NT corn yields at each location, 2008.

N Source	Belleville	DSAC	Average
----- <i>Corn Grain Yields (bu/acre)</i> -----			
UAN Side Injected	126 ab	182 a	154
Urea Broadcast	91 e	151 d	121
Urea+Agrotain	122 bc	169 b	145
ESN Broadcast	139 a	166 bc	153
SuperU Broadcast	109 cd	163 bc	136
UAN Broadcast	111 bcd	160 bcd	136
UAN+Agrotain	121 bc	160 bcd	141
UAN+AgrotainPlus	118 bcd	159 bcd	139
UAN+CaTs	104 de	157 bc	131
UAN+AgrotainDF	124 bc	165 bc	145
Average	116.5	163.4	
LSD _{0.05} N Source	15.0	10.2	
Statistics:			
<i>N Source (NS)</i>	***	***	
<i>N Rate (NR)</i>	***	***	
<i>NS x NR</i>	NS	NS	
----- <i>Corn Grain Yields (bu/acre)</i> -----			
<u>N Rate</u>			
0	54	137	96
60	88	158	123
120	120	170	146
180	152	176	164
240	168	176	172
Check (% of Max.)	32%	78%	
Statistics:			
<i>NR linear</i>	***	***	
<i>NR quadratic</i>	***	***	

*, **, and *** refer to significance at the 10, 5 and 1% levels, respectively. NS = nonsignificant.

Table 5. Optimum N rate, yield at optimum N and NUE for each N source averaged across locations, 2008.

N Source	CT Surface Applied			CT Incorporated			NT Surface		
	Opt. N	Yield @ opt	NUE	Opt. N	Yield @ opt	NUE	Opt. N	Yield @ opt	NUE
	(lb N/a)	(bu/a)	(lb N/bu)	(lb N/a)	(bu/a)	(lb N/bu)	(lb N/a)	(bu/a)	(lb N/bu)
UAN Side Injected	n/a	n/a	n/a	n/a	n/a	n/a	238	193	1.23
Urea Broadcast	189	207	0.91	188	209	0.90	240	142	1.69
Urea+Agrotain	203	213	0.95	178	208	0.85	191	173	1.11
ESN Broadcast	178	200	0.89	180	214	0.84	240	197	1.22
SuperU Broadcast	209	216	0.97	184	212	0.87	199	160	1.24
UAN Dribble	201	202	1.00	220	210	1.05	213	160	1.33
UAN+Agrotain	226	214	1.05	196	206	0.95	228	171	1.33
UAN+AgrotainPlus	210	203	1.03	228	211	1.08	240	175	1.38
UAN+CaTs	188	200	0.94	207	207	1.00	240	160	1.50
UAN+AgrotainDF	n/a	n/a	n/a	n/a	n/a	n/a	240	179	1.34

Figure 1. Rainfall after N application by locations, 2008.

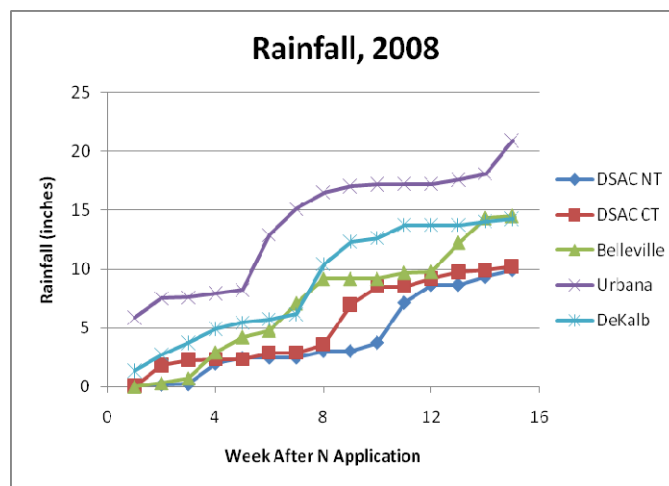


Figure 2. Effects of N sources on CT corn yields, Dixon Springs, 2008.

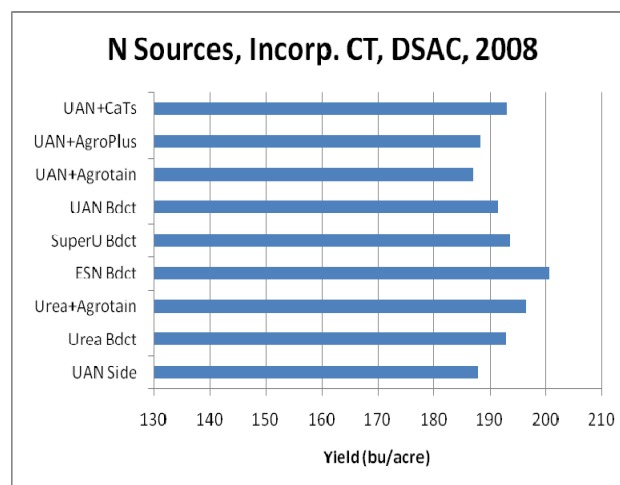
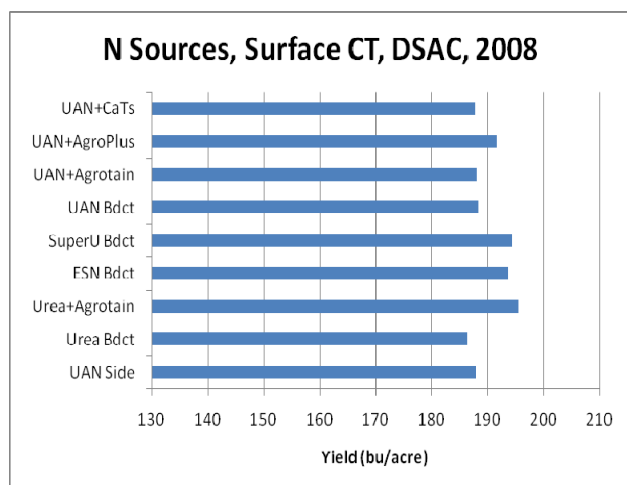


Figure 3. Effects of N sources on CT corn yields, Belleville, 2008.

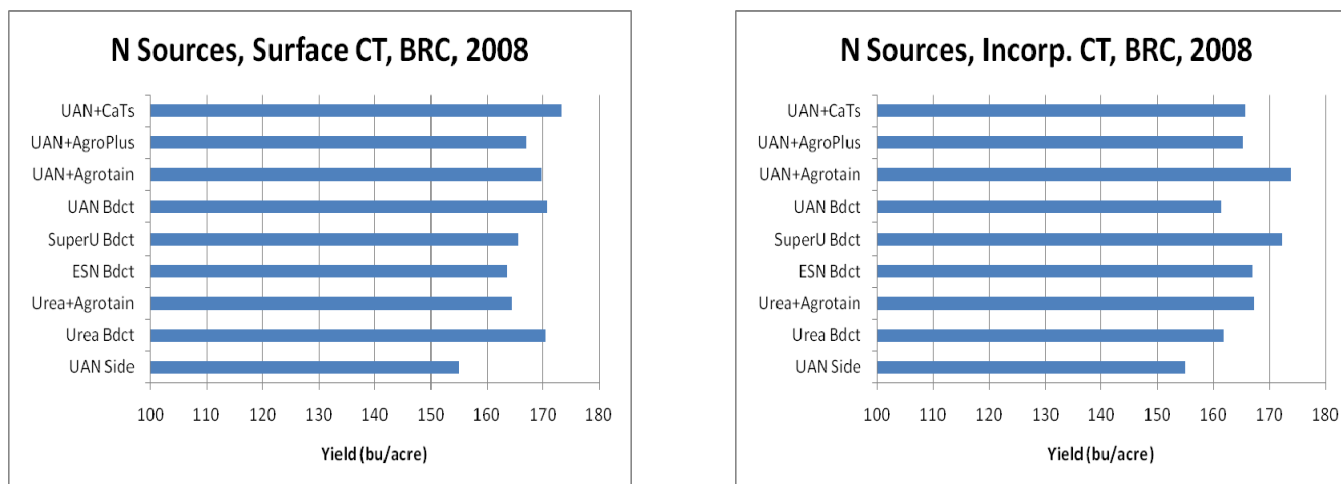


Figure 4. Effects of N sources on CT corn yields, Urbana, 2008.

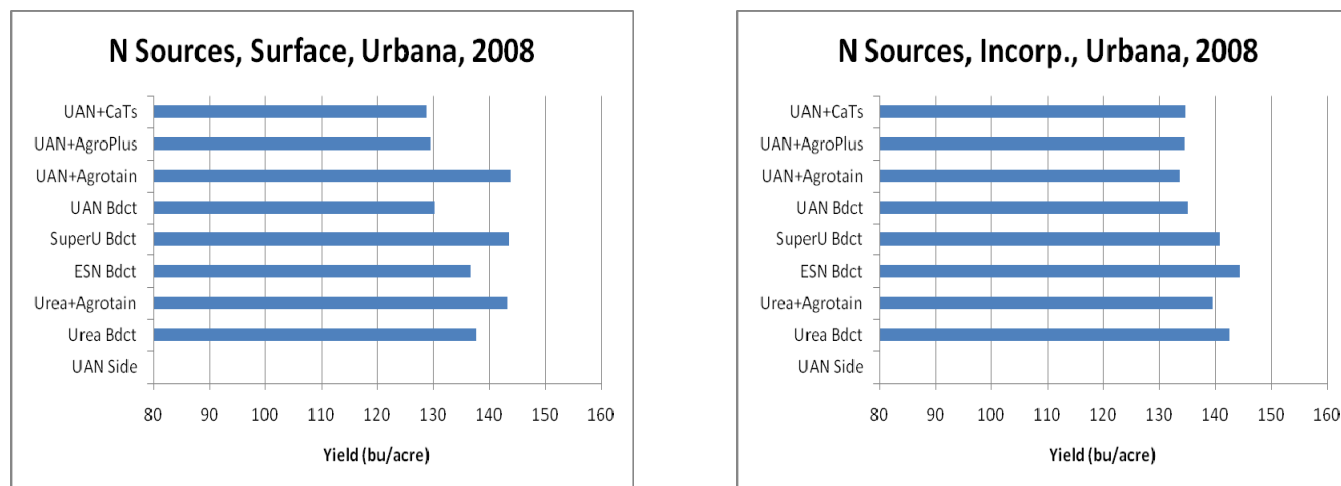


Figure 5. Effects of N sources on CT corn yields, DeKalb, 2008.

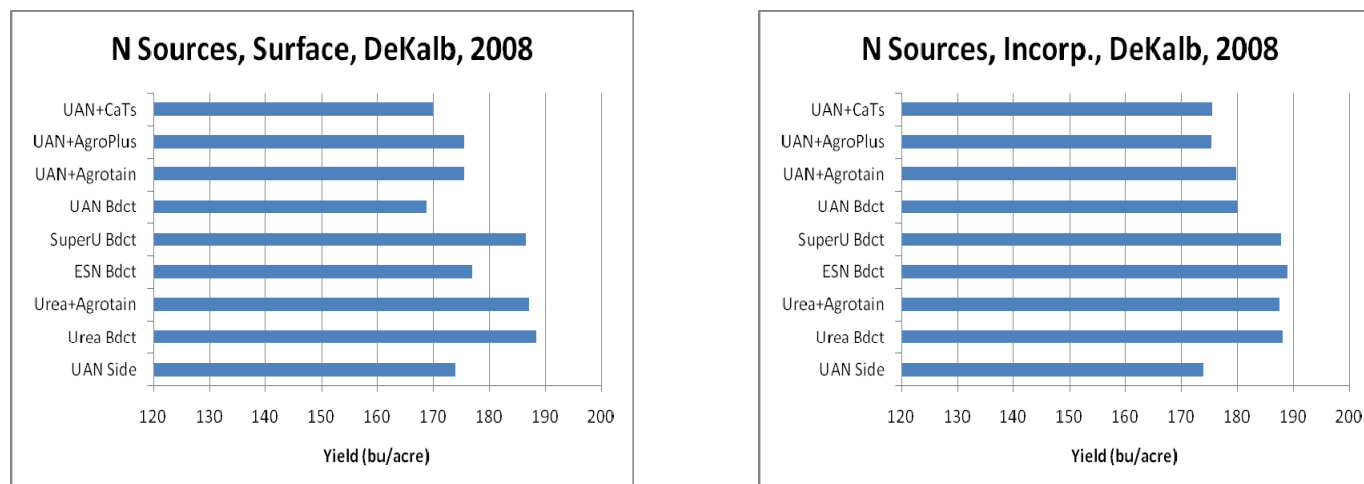


Figure 6. Effects of N sources on NT corn yields at Belleville and Dixon Springs, 2008.

