RESCUE NITROGEN APPLICATIONS FOR CORN (*ZEA MAYS*)

Kelly A. Nelson, Peter C. Scharf, Gene Stevens, and Bruce A. Burdick
University of Missouri Dep. of Agronomy
Novelty, Columbia, Portageville, and Albany

Abstract: Rescue N (nitrogen) applications in a standing corn crop may be necessary when wet conditions prevent preplant N applications or loss of N was suspected due to wet conditions after application. Field research at Albany, Columbia, Novelty, and Portageville in 2003 and 2004 evaluated the impact of AN (ammonium nitrate), UAN (urea ammonium nitrate), urea, and urea plus NBPT (Agrotain®) applied broadcast and between-row (BR) as a preplant or postemergence application to 1, 2, 3, and 4 ft corn. Nitrogen applied BR injured corn on average less than 5% 7 days after treatment except UAN applied to 2 ft tall corn. Broadcast applied N injury was ranked UAN (32-55%) > AN (14-26%) > urea (4-8%) = urea plus NBPT (5-10%). BR application of AN, UAN, or urea plus NBPT to corn 1 to 4 ft tall had optimal grain yields at 60 to 100% of the sites; however, BR application of urea was consistent at 80 to 100% of the sites when applied to 3 to 4 ft tall corn. Broadcast applications of N sources with optimal grain yields at 60 to 100% of the sites included: UAN up to 1 ft tall corn, AN 1 to 2 ft tall corn, and urea or urea plus NBPT 2 to 4 ft tall corn.

INTRODUCTION

Rescue N applications in a standing corn crop may be necessary when wet conditions prevent preplant N applications or loss of N was suspected due to wet conditions after application. In these situations, either tractor-mounted or high-clearance-mounted applicators can sidedress N fertilizer between corn rows, avoiding leaf burn. These applicators are not always available, or may be configured for other uses such as spraying herbicides, consequently, broadcast applications may be easier to accomplish. In addition, broadcasting N fertilizer by airplane is another option for rescue applications of N when soil conditions are too wet to carry traffic. Broadcast applications of N will cause leaf burn, but little if any research has been conducted to measure how much yield is lost due to leaf injury for various application times and nitrogen forms. The amount of yield recovered may depend on the stage at which N is applied. Understanding yield loss associated with nitrogen burn at different stages of corn development would help corn producers to make informed decisions about whether to attempt rescue N applications and what type of application equipment to use. The objective of this study was to evaluate yield response of corn to rescue N applications, including broadcast applications that cause leaf burn and to evaluate dry and liquid nitrogen sources.

MATERIALS AND METHODS

Field research was conducted at the University of Missouri Greenley Research Center near Novelty in 2003 and 2004 (40.035997 N, 92.243783 W), Bradford Research and Extension Center near Columbia in 2003 and 2004 (38.894165 N, 92.274145 W),

Hundley-Whaley Research Center near Albany in 2003 (40.251282 N, 94.326977 W), and Delta Center near Portageville in 2003 and 2004 (36.427945 N, 89.700234 W). The Albany site experienced a severe hailstorm prior to the 4 ft application timing in 2004 and was abandoned. The soil was a Putnam silt loam (fine, montmorillonitic, mesic Mollic Albaqualf), Mexico silt loam (fine, montmorillonitic, mesic Vertic Albaqualfs), Grundy silt loam (fine, montmorillonitic, mesic Aquic Argiudolls), and Tiptonville sandy loam (fine-silty, mixed, thermic Typic Argiudolls) at Novelty, Columbia, Albany, and Portageville, respectively. Researchers at each site utilized management practices commonly used by farmers in the area. Field information about the locations and selected management practices is shown in Table 1.

Research was arranged as a randomized complete block design with four replications at Novelty, Columbia, and Portageville and three replications at Albany. Ammonium nitrate (AN), urea ammonium nitrate (UAN), urea, or urea plus NBPT at 1 qt/ton was applied broadcast or between the row at 150 lb N/acre preplant and to 1, 2, 3, and 4 ft tall corn except between-row (BR), preplant urea and urea plus NBPT at 1 gallon/ton; 1 ft corn treated with urea at Novelty, Columbia, and Albany; and 3 ft corn treated with urea and urea plus NBPT at Novelty, Columbia, and Albany. NBPT is a urease inhibitor and is n-(n-butyl) thiophosphoric triamide (Agrotain®) combined with the solvent n-methyl pyrrolidone. Corn injury from 0 (no visual crop injury) to 100% (complete crop death) was evaluated 7 and 14 days after treatment based on the combined visual effects of N source on necrosis, chlorosis, and stunting. Corn was harvested with a small-plot combine and final weight adjusted to 15% moisture.

Injury data were subjected to ANOVA and reported by location due to interactions between locations and different environmental conditions. Yield data were grouped and discussed according to low, medium, and high yield environments. Data were subjected to an analysis of variance and means separated using Fisher's Protected LSD at $p = 0.05$.

RESULTS

Injury. Preplant N at 150 lb/a did not injure corn (data not presented). Nitrogen applied between the rows injured corn on average less than 5% 7 DAT except UAN applied to 2 ft tall corn (Table 2). However, injury was less than 4% for all N sources 14 DAT. Broadcast applied N injury was ranked UAN > AN > urea = urea plus NBPT. Average broadcast N injury was 32-55%, 14-26%, 4-8%, and 5-10% for UAN, AN, urea, and urea plus NBPT 7 DAT, respectively, depending on the application timing. Complete recovery was evident by 28 DAT for all N sources except UAN applied broadcast to corn that was 2, 3, or 4 ft tall and AN applied broadcast to 3 or 4 ft tall corn (visual observation).

Yield response. Grain yield was affected by the yield potential of the environment, injury, N source, and application timing. Data were presented separately for each location except Columbia and Albany in 2003 since both locations experienced drought conditions. All rescue N application treatments had grain yields similar to preplant N except UAN applied broadcast to 4 ft corn which reduced grain yield 34 and 23 bu/a when compared to UAN applied preplant and the untreated control, respectively (Table 3). Preplant, broadcast applied urea plus NBPT, urea plus NBPT applied broadcast to 2 ft

tall corn, urea applied BR to 2 ft tall corn, and AN applied BR to 2 ft tall corn had grain yields 17 to 21 bu/a greater than the untreated control.

The Novelty site in 2003 was a medium grain yield environment (Table 3). All treatments increased corn grain yield when compared to the untreated control. All rescue N application treatments had grain yields similar to or greater than the preplant N applications except UAN applied broadcast to 4ft corn. Corn grain yield was probably reduced due to injury at this application timing. Urea applied broadcast to 3 and 4 ft corn, AN applied BR to 3 and 4 ft corn, and UAN applied BR to 3 and 4 ft corn increased grain yield 15 to 23 bu/a when compared to preplant N applications. UAN applied broadcast to 4 ft corn reduced grain yield 18 bu/a when compared to UAN applied preplant.

Rainfall and temperature were optimal for corn in 2004. The Columbia and Novelty sites were in high yield environments (Table 4). Grain yields at Columbia were maximized at the 1 ft application timing when compared to other application timings. Corn grain yield, when AN was applied broadcast or BR at the 1 and 2 ft corn timings, was similar to the preplant control. UAN applied broadcast to 1 ft tall corn had grain yields similar to UAN applied preplant treatment; however, corn treated BR up to 2 ft tall or 4 ft timing had grain yields similar to the preplant control. A broadcast application of urea or urea plus NBPT up to 3 ft tall corn had grain yields similar to preplant treatments. Grain yield for urea and urea plus NBPT was 23 and 26 bu/a greater at the 1 ft timing than preplant urea and urea plus NBPT controls, respectively. At Novelty, the 2 ft N applicationg timing had the highest grain yields. AN applied broadcast or BR to corn 1 to 4 ft tall had grain yields similar or up to 34 to 36 bu/a greater than the preplant timing. A broadcast or BR application of UAN to corn 1 to 3 ft tall had grain yields similar to the preplant control. Corn grain yield in urea or urea plus NBPT applied broadcast or BR up to 2 ft tall was similar to the preplant control; however, grain yields were similar to the untreated control at the 3 and 4 ft application timings.

The Portageville site had a high yield environment in 2003 and a medium yield environment in 2004 (Table 5). The preplant and 1 ft tall corn application timings had the greatest corn grain yields at Portageville in 2003 and 2004. Corn grain yield was similar to the preplant control when AN was applied broadcast and UAN was applied BR up to 1 ft tall corn; UAN was applied broadcast, urea plus NBPT applied broadcast or BR up to 2 ft tall corn; and AN was applied BR up to 4 ft tall corn. Corn plant population was reduced in 2004 by birds that reduced overall grain yields and increased variability. The 1 ft tall corn application timing of broadcast and BR UAN or urea plus NBPT had grain yields 32 to 45 bu/a greater than the preplant timing. UAN applied broadcast to 3 and 4 ft tall corn and AN applied BR to 3 ft tall corn had grain yields 69 to 112 bu/a lower than the preplant controls.

SUMMARY AND RECOMMENDATIONS

Rescue N applications to corn 1 to 4 ft tall with different N sources had grain yields similar or greater than preplant timings depending on the application method and N source. Corn with delayed N applications due to wet conditions may have the same yield potential as a preplant application. Crop response to rescue N applications depended on the N source and whether the source was applied broadcast or BR. Recommendations on

rescue N application methods and sources depend on a consistent, high yield response (Table 6). Urea and urea plus NBPT were the least injurious N sources when applied broadcast or BR. Urea or urea plus NBPT broadcast applied from 2 to 4 ft tall corn had corn grain yields similar to the highest yielding N application at that timing 60 to 100% of the sites. A BR application of urea was the most consistent at the 3 and 4 ft tall corn application timings. Urea plus NBPT, AN, and UAN applied BR from 1 to 4 ft tall corn had high grain yields at 60 to 100% of the sites evaluated. AN may be broadcast applied to corn up to 2 ft tall. AN may concentrate in the whorl or on the leaf and cause necrosis of the plant tissue. An early broadcast application of AN provided sufficient time for the corn plant to recover from leaf burn. UAN applied broadcast may be utilized on 1 ft tall corn, but did not provide consistent yields at the 2 ft application timing. Necrosis of corn leaf tissue on plants 3 to 4 ft tall reduced grain yield when compared to other N sources. Based on this research, Figure 1 summarizes the recommended application timing for different N sources and application method.

Table 1. Field information and selected management practices for Novelty, Albany, Portageville, and Columbia in 2003 and 2004.

	Novelty		Albany	Portageville		Columbia	
	2003	2004	2003	2003	2004	2003	2004
Planting Date	19-May	9-Apr	7-May	2-Apr	5-Apr	23-Apr	26-Apr
Hybrid	Pioneer 33P67	Pioneer 33P67	DKC60-19	Cropland 818BT	Dyna-Gro 57P35	Asgrow RX 7118RR	DK C60-19
Seeding rate (seeds/a)	29,900	29,900	28,500	30,000	30,000	29,100	30,200
Tillage	No-till	No-till	Minimum	Disk, bed, harrow	Disk, bed, harrow	Field cultivate, mulch	No-till
Harvest Date	22-Oct	22-Sep	30-Sep	15-Sep	9-Sep	26-Sep	23-Sep

Table 2. Average broadcast and between-row (BR) ammonium nitrate (AN), urea ammonium nitrate (UAN), urea, and urea plus NBPT injury to corn 7 and 14 days after treatment (DAT) for 1, 2, 3, and 4 ft corn application timings in 2003 and 2004. Data were averaged over all seven site years. All nitrogen sources were applied at 150 lb N/acre. NBPT was applied at 1 qt/ton.

	1 ft		2 ft		3 ft		4 ft	
	7 DAT	14 DAT	7 DAT	14 DAT	7 DAT	14 DAT	7 DAT	14 DAT
Untreated	0	0	0	0	0	0	0	0
Between-row (BR)								
AN	1	0	2	1	1	0	1	0
UAN	2	1	12	3	5	2	4	4
Urea	0	0	1	1	2	0	2	0
Urea + NBPT	0	0	1	1	1	0	0	0
Broadcast								
AN	15	6	22	12	26	20	14	9
UAN	32	16	41	20	53	32	55	44
Urea	4	1	8	3	7	2	5	1
Urea + NBPT	5	1	10	3	8	2	5	2

Table 3. Corn grain yield and gross margin as affected by ammonium nitrate (AN), urea ammonium nitrate (UAN), urea, and urea plus NBPT applied broadcast and between-row (BR) as preplant and sidedress to 1, 2, 3, and 4 ft corn in low (Columbia and Albany, 2003) and medium (Novelty, 2003) yield environments.

	Columbia and Albany, 2003					Novelty, 2003				
	Preplant	1 ft	2 ft	3 ft	4 ft	Preplant	1 ft	2 ft	3 ft	4 ft
Treatment	Yield (bu/a)									
Untreated	70					58				
Broadcast										
AN	86	82	76	78	86	115	122	112	113	110
UAN	81	74	79	67	47	108	114	110	106	90
Urea	81	81	84	75	77	105	115	118	128	125
Urea + NBPT	87	81	87	79	80	111	116	126	120	120
Between-row (BR)										
AN	80	85	83	91	86	110	112	118	126	125
UAN	86	84	77	80	80	105	114	118	124	125
Urea	—	—	90	—	69	—	—	110	—	120
Urea + NBPT	—	80	80	—	83	—	118	121	—	120
LSD ($p \leq 0.05$)	17					15				

Table 4. Corn grain yield and gross margin as affected by ammonium nitrate (AN), urea ammonium nitrate (UAN), urea, and urea plus NBPT applied broadcast and between-row (BR) as preplant and sidedress to 1, 2, 3, and 4 ft corn in high (Columbia and Novelty, 2004) yield environments.

	Columbia, 2004					Novelty, 2004				
	Preplant	1 ft	2 ft	3 ft	4 ft	Preplant	1 ft	2 ft	3 ft	4 ft
Treatment	Yield (bu/a)									
Untreated	106					86				
Broadcast										
AN	236	239	209	182	174	226	240	243	219	225
UAN	205	214	155	106	80	185	175	207	175	130
Urea	217	240	210	209	195	164	204	238	84	99
Urea + NBPT	225	251	227	211	188	214	210	243	83	96
Between-row (BR)										
AN	217	237	226	193	202	218	227	252	254	237
UAN	217	217	209	192	203	198	201	250	227	206
Urea	—	—	194	—	196	—	—	245	—	99
Urea + NBPT	—	235	227	—	197	—	200	247	—	96
LSD ($p \leq 0.05$)	21					27				

Table 5. Corn grain yield and gross margin as affected by ammonium nitrate (AN), urea ammonium nitrate (UAN), urea, and urea plus NBPT applied broadcast and between-row (BR) as preplant and sidedress to 1, 2, 3, and 4 ft corn in high (Portageville, 2003) and medium (Portageville, 2004) yield environments.

	Portageville, 2003					Portageville, 2004				
	Preplant	1 ft	2 ft	3 ft	4 ft	Preplant	1 ft	2 ft	3 ft	4 ft
Treatment	Yield (bu/a)									
Untreated	102					88				
Broadcast										
AN	177	178	136	84	93	113	107	108	96	100
UAN	162	181	130	114	56	88	120	113	55	50
Urea	208	155	160	159	134	120	117	125	114	99
Urea + NBPT	187	154	171	117	140	100	137	113	111	95
Between-row (BR)										
AN	170	202	141	143	152	139	112	115	101	112
UAN	181	176	141	121	128	100	140	96	125	106
Urea	—	143	155	146	128	—	125	95	114	100
Urea + NBPT	—	178	175	141	117	—	145	108	112	114
LSD ($p \leq 0.05$)	33					29				

Table 6. Rescue N application recommendations for ammonium nitrate (AN), urea ammonium nitrate (UAN), urea, and urea plus NBPT applied broadcast and between-row (BR) to 1, 2, 3, and 4 ft corn. Number of sites with grain yields similar to the highest yielding treatment at the specified application timing[a].

	Corn height at application			
N application method and source	1 ft	2 ft	3 ft	4 ft
Broadcast				
AN	4 of 5	4 of 5	1 of 5	2 of 5
UAN	3 of 5	1 of 5	NR[b]	NR[b]
Urea	2 of 5	5 of 5	4 of 5	4 of 5
Urea + NBPT	2 of 5	5 of 5	3 of 5	4 of 5
Between-row (BR)				
AN	4 of 5	4 of 5	5 of 5	5 of 5
UAN	3 of 5	3 of 5	3 of 5	4 of 5
Urea	1 of 2[c]	2 of 5	2 of 2[c]	4 of 5
Urea + NBPT	4 of 5	5 of 5	2 of 2[c]	3 of 5

[a]Site-years with grain yields similar to the highest yielding rescue N application treatment at Novelty in 2003 and Portageville in 2004 (medium yield environments), and Portageville in 2003, Columbia in 2004, and Novelty in 2004 (high yield environments).
[b]NR, not recommended.
[c]Portageville only.

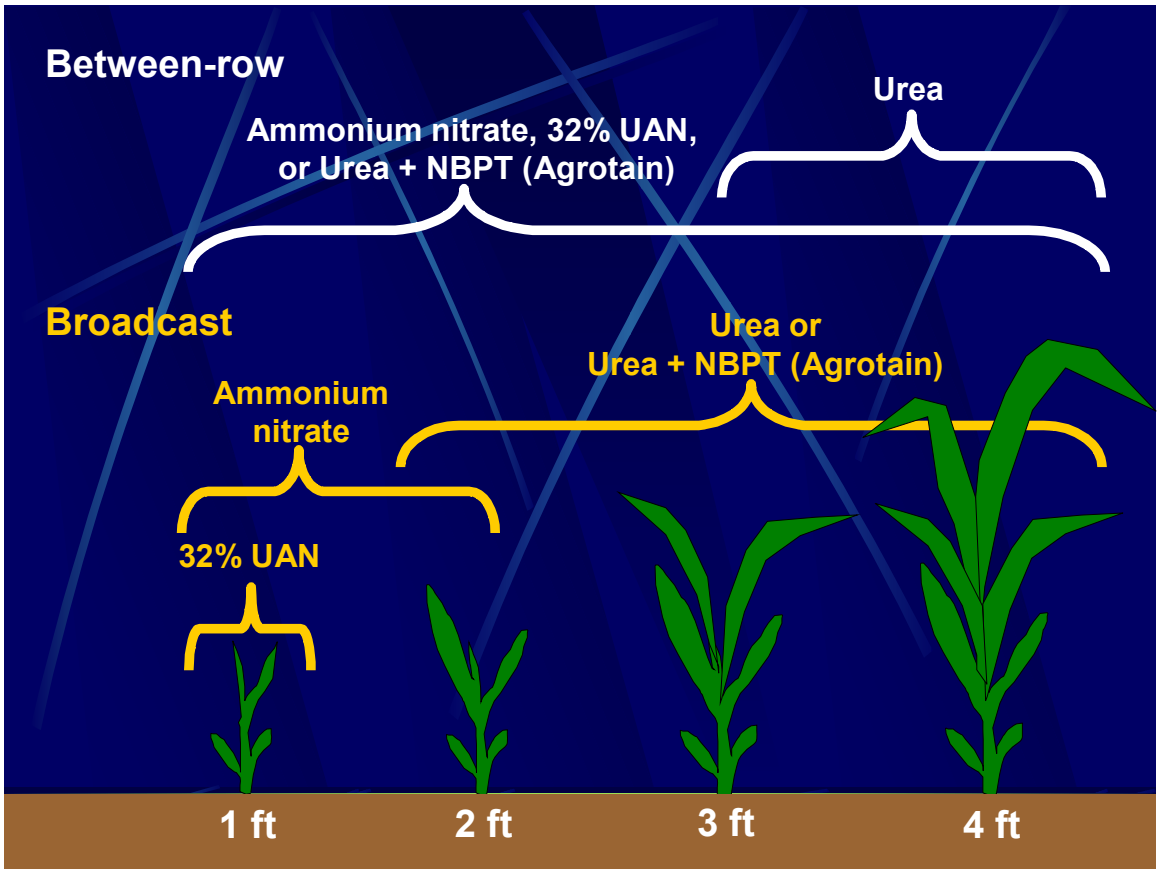

Figure 1. Rescue N application recommendations for N sources applied to 1 to 4 ft tall corn between the row or broacast.