Fluid Fertilizer Alternatives to Fall N Applications

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Abstract

Fall application of nitrogen (N) is under scrutiny throughout the Corn Belt because of increased potential for loss to ground and surface waters in the spring. In addition, conservation tillage practices are being strongly advocated in corn-soybean rotations to minimize soil erosion and sediment delivery to surface water. Two studies were conducted on a Webster clay loam at Waseca, MN in 2001 and 2002 to determine the effects of various N management strategies on corn yield in a one-pass, field cultivate system and a strip-till system. Various combinations of sources (anhydrous ammonia (AA), urea, and UAN) and application times (fall, spring preplant, planting time, and sidedress) were applied in each tillage system.

Above-normal precipitation during these two growing seasons was marked by a record amount (16.25") between April 5 and June 15, 2001 and 7.15" in June, 2002. These wet spring conditions increased the denitrification and leaching potential of fall-applied N and undoubtedly favored the split and sidedress N treatments. Averaged across the two years, greatest grain yields, total N uptake, and apparent N recovery for both tillage studies occurred with the "weed and feed" program where UAN was split between 40 lb N/A broadcast preemergence and 60 lb N/A sidedressed. Other high yields were obtained with split applications where either 40 or 60 lb N/A as UAN was applied at V3 for the one-pass tillage system. For the strip-tillage system, high yields were obtained when 80 or 100 lb N/A as UAN were sidedressed or 100 lb N/A as AA was spring, preplant applied. Lowest yields and N recovery for both tillage systems tended to occur most frequently with fall-applied AA and when 40 lb N/A as UAN was dribbled next to the seed row at planting.

Introduction

Fall application of nitrogen (N) is under severe scrutiny throughout the Corn Belt largely because of greater potential for N loss in the spring before crop uptake. Numerous studies have documented significant loss of nitrate-N in subsurface tile drainage water in February through June. Some long-term studies show that 65-70% of the annual drainage discharge and nitrate losses occur in April, May, and June. These early-season losses are being associated with development of the hypoxic zone in the Gulf of Mexico. For these reasons, fall application of N is being questioned and is in jeopardy throughout much of the Mississippi River Basin.

Soil erosion and sediment delivery to surface water bodies are also burning issues as society looks for improved water quality. Agriculture has a significant role to play in this process and for years has advocated the use of conservation tillage practices to minimize erosion and sediment loss to surface water bodies.

Two distinctly different conservation tillage systems involving no primary tillage after soybeans are used in this research project. The one-pass system involves a full-width field cultivator just prior to planting corn. This is a popular system that creates a favorable, weed-free seed bed and is extremely suitable for incorporating spring preplant fertilizers and herbicides. The strip-till system is a newer tillage system and has generated much interest throughout the Corn Belt. In the fall after soybean harvest, strips spaced on 30-inch centers are tilled about 8 inches deep with knives mounted on a tool bar much like an anhydrous ammonia applicator. The knife tills an area 4 to 6 inches wide and leaves a l to 2 –inch berm of residue-free soil. The inter-strip area is left untilled and is covered with residue. Placement of fertilizer, especially P and K, about 6 inches deep at the time of strip preparation is considered to be an agronomic and environmental benefit of strip tillage. Consequently, this tillage system is being heavily promoted. As soon as field conditions are suitable, corn is planted directly in the strips. This early planting is deemed desirable by farmers.

Application of N in the strip-till system is a dilemma, however. Most producers want to do the strip-till operation, which includes placement of fertilizer, shortly after soybean harvest. This is not favorable to good N management because of warm temperatures resulting in nitrification of the early-fall applied N and the potential for greater N losses. Waiting until later in the fall when soil temperatures have dropped to less than 50^{o}F, a favorable time for N application, is considered by most farmers to be too late for doing strip tillage because of the greater risk of inclement weather that could either impair or negate the fall operation. Spring strip tillage is generally not acceptable in most soils.

The objectives of this study are to:

(1) determine the effect of planting time and sidedress applications of UAN as alternatives to traditional single fall and spring preplant N treatments for corn production after soybeans for two distinctly different tillage systems,

(2) evaluate application methods for “near-the-row” placement of UAN, and

(3) provide fertilizer N management alternatives and guidelines for corn producers, crop consultants, local advisors, and the fertilizer industry.

Experimental Procedures

These experiments were conducted on a tile drained Webster clay loam soil at the Southern Research and Outreach Center, Waseca, MN. The tile lines were spaced 75’ apart and all rows were perpendicular to the tile lines. Soybean was the previous crop each year and was not tilled in the fall. All N treatments, except the control, received a total of 100 lb N/A. This is about 15% less than the University of Minnesota recommends for an expected yield of 150 to 174 bu/A, but we felt we could more clearly identify differences in N application methods with this lower N rate. Each plot measured 10’ wide (4-30” rows) by 50’ long. Corn was planted at 33,000 plants per acre in May. The plots were then thinned to a uniform population of 31,000 plants/acre. Excellent weed control was obtained with a broadcast application of Surpass followed by a broadcast application of Liberty. Emergence counts were taken during a 10-day period in May to determine if the planting time treatments affected plant emergence. Plant height measurements were taken (V8 stage) by measuring the extended leaf height of 10 plants per plot. Leaf chlorophyll measurements were made at the R1 stage. Stover yields were taken from 15' of row at physiological maturity. Grain yields and moisture content were taken by combine harvesting the center two rows of each plot after end-trimming to a length of 47’. Corn stover and grain samples were saved, dried, ground, and submitted for total N analyses. Procedures specific to each of the studies follow.

<u>One-pass, field cultivate tillage</u>

Anhydrous ammonia (AA) was fall-applied in late October and spring-applied in mid-April. Urea and UAN were preplant applied and followed by field cultivation the next day. Planting-time treatments of UAN were either dribbled on the soil surface within 2” of the row or were broadcast sprayed along with the herbicides. Sidedress treatments of UAN were coulter-injected midway between the rows at the V3 stage.

<u>Strip tillage</u>

Strip tillage was conducted in late October, and anhydrous ammonia with and without nitrapyrin (N-Serve) was applied to selected treatments. Urea + Agrotain was broadcast applied in late April. Anhydrous ammonia without nitrapyrin was spring-applied midway between the strips in late April. The corn was planted directly into the strip areas in early May without any secondary tillage. UAN was applied at planting time by either dribbling on the soil surface about 2” from the row, injecting about 3” deep and 2” from the seed row with a coulter mounted on the planter, or broadcast spraying on the soil surface at the time of preemergence herbicide application. Sidedress UAN treatments were coulter injected midway between the rows at the V3 stage.

Results and Discussion

<u>One-pass, field cultivate tillage</u>

In 2001, corn yields shown in Table 1 were lower than desired due to stress conditions during the growing season. A record amount of rainfall (16.25”) fell between April 5 and June 15. This was followed by hot and dry conditions from mid-June through mid-August when rainfall totaled only 4.9” (3.5” below normal). Severe stress symptoms (rolled corn leaves) were visible many days during July and early August due to the poor root systems resulting from the earlier wet conditions. Although a 40 bu/A response to N was obtained, the yields were likely not a very good indicator of differential responses to N application methods. Statistical differences [LSD (0.10) = 10 bu/A] were found among the N treatments, however. In general, lowest yields were found with split N treatments where UAN was dribbled next to the row in conjunction with fall-applied AA. Plant population and emergence rates were not affected by the N treatments, however. Broadcasting UAN on the soil surface followed by field cultivation and planting 5 and 6 days later, respectively, was also a low-yielding treatment. On the other hand, the two highest yielding treatments were split applications of UAN partitioned between planting and sidedressing. The four highest yielding treatments all received some sidedress-applied UAN.

In 2002, corn yields shown in Table 1 exceeded 200 bu/A for some of the N treatments. These high yields were due in part to favorable rainfall during the May-September growing season (20.18"), especially in August (6.08"), and 6% above-normal growing degree units for the growing season which ended on Sept. 24. Wet conditions during June (7.15") likely caused some leaching and denitrification. Dry (2.68") and hot conditions in July caused some plant stress but apparently did not significantly harm corn yield.

Yield responses to the 100-lb N rate compared to the 0-lb rate ranged from 38 to 67 bu/A. Yields among the 100-lb N treatments ranged from 180 to 209 bu/A with an LSD (0.10) of 17 bu/A. In general, greatest yields were obtained with (a) UAN split-applied between planting and sidedress, (b) fall applied AA in combination with 20 or 40 lb N/A as sidedress UAN, (c) fall applied AA with N-Serve, and (d) single preplant applications of AA, urea or UAN. Lowest yields occurred for the split treatment of fall AA plus either 20 or 40 lb N/A as UAN dribbled on the soil surface near the row at planting.

Two-year (2001-02) average corn yields show the greatest N response to occur with either UAN split-applied between planting and sidedressing or with a split application of fall AA and either 20 or 40 lb N/A sidedressed as UAN (Table 1). Lowest yields were obtained with 60 or 80 lb N/A as AA plus N-Serve in the fall with either 40 or 20 lb N/A as UAN dribbled near the seed row at planting.

Grain N concentration and total N uptake, averaged across the two years, were greatly increased over the control by the N treatments (Table 2). Little difference in grain N concentration existed among the treatments receiving N. Highest N concentrations occurred with split applications of UAN (planting and sidedress) and a spring preplant application of AA + N-Serve. Lowest concentrations were found when AA was applied at the 60-lb N rate in the fall followed by 40 lb N as UAN dribbled near the row at planting or sidedressed at V3. Total N uptake was greatest with split applications of UAN where 40% was applied at planting and 60% at V3, resulting in apparent recovery of 65 to 73% of the fertilizer N. Lowest total N uptake and N recovery (46-48%) occurred with split applications of fall AA and planting-time dribble application of UAN.

Strip tillage

In 2001, corn yields shown in Table 3 were somewhat lower than desired but greater than those in the one-pass tillage study. The stress conditions during the growing season were similar for both studies, but this experiment was located in a somewhat lower position in the landscape where available water during late July and early August was slightly more plentiful compared to the one-pass tillage experiment. Yield responses to N ranged from about 40 bu/A for the single fall applications of AA to 50-60 bu/A for the split applications (planting and sidedress) applications of UAN. Although considerable variability exists in the yield data, yields were generally greater with split applications of N (preplant + planting or planting + sidedress) compared to single applications of AA in the fall or urea in the spring before planting. Also, the yield for the single sidedress application of UAN was significantly lower than for three of the split application treatments. The wet conditions in April-June likely favored the spring and split applications of N, but late-season stress caused higher variability, making data interpretation more difficult.

Corn yields for 2002 shown in Table 3 were very similar to those obtained in the one-pass, field cultivate system. Yield responses to N compared to the 0-lb control ranged from 51 to 73 bu/A. Among the 100-lb N treatments, yields ranged from 182 to 204 bu/A with a LSD (0.10) of 14 bu/A. The highest yield was obtained when all of the UAN was applied sidedress; whereas, lowest yields occurred when UAN was split between 40 lb N/A applied near the row at planting and 60 lb N/A applied sidedress. Lower yield with the dribbled UAN treatment was similar to that found in the one-pass tillage system. Other high-yielding treatments included: (a) fall and preplant AA, (b) preplant urea, and (c) split applications of UAN with 20 lb N/A at planting and 80 lb N/A, or (d) 40 lb N/A broadcast preemergence as a "weed and feed" treatment followed by 60 lb N/A sidedressed.

Two-year average yield data shown in Table 3 indicate greatest N response with the "weed and feed" application of 40 lb N/A as UAN followed by 60 lb N/A of sidedressed UAN. Other high-yielding treatments not significantly different from the above treatment include: spring preplant AA, sidedress UAN, and 20 lb N/A as UAN at planting with 80 lb N/A as either urea at planting or UAN sidedressed. The lowest yielding treatments included fall application of AA with or without N-Serve and the split treatment where 40 lb NA was dribbled on the soil surface next to the seed row at planting followed by 60 lb N/A sidedressed.

Similar to the one-pass tillage system, grain N concentration and total N uptake, averaged across the two years, were greatly increased over the control by the N treatments in this strip tillage study (Table 4). Highest grain N concentrations and total N uptake tended to be associated with the single sidedress UAN treatment and the UAN treatments split 20:80 or 40:60 between planting and sidedress (V3). Lowest grain N concentrations and total N uptake occurred when AA was fall-applied or UAN was split-applied by dribbling 40 lb N/A next to the row at planting and sidedressing 60 lb N/A at V3. Apparent recovery of the fertilizer N was quite high, ranging from a low of 56 to 58% for the fall AA treatments to 73 to 77% for those treatments where 60 to 100% of the N was sidedress-applied as UAN at V3.

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Table l. Corn grain yield as affected by time of N application and source of N in a one-pass, field cultivate system.

N Treatment				Yield		
Fall	Spring preplant	Planting	Sidedress[1/]	2001	2002	2001-02 Avg.
- - - - - - - - - -N Source/Rate (lb N/A) [2/] - - - - - - - - - - -				- - - - - - - - - bu/A - - - - - - -		
0	0	0	0	94	142	118
		- - - - - - UAN - - - - - -				
AA+NS/100	-	-	-	137	196	167
AA+NS/80	-	20 Dribble	-	127	180	154
AA+NS/80	-	-	20	140	198	169
AA+NS/60	-	40 Dribble	-	128	181	155
AA+NS/60	-	-	40	138	200	169
-	AA/100	-	-	134	195	164
-	AA+NS/100	-	-	136	194	165
-	U/100/BI	-	-	134	196	165
-	UAN/100/BI	-	-	129	197	163
-	-	40 Dribble	60	142	209	175
-	-	40 Spray	60	148	206	177
	LSD (0.10):			10	17	10
	CV(%):			6.6	7.5	7.4

[1/] All sidedress treatments were coulter-injected midway between the rows.

[2/] AA= anhydrous ammonia, NS = N-Serve, U= urea, UAN = urea-ammonium nitrate, and BI = broadcast and incorporated.

Table 2. Two-year average grain N concentration, total N uptake at physiological maturity, and apparent fertilizer N recovery as affected by time of N application and source of N in a one-pass, field cultivate system.

N Treatment				Grain N	Total N	Apparent
Fall	Spring preplant	Planting	Sidedress[1/]	Conc.	Uptake	N Recov.
- - - - - - - - - -N Source/Rate (lb N/A) [2/] - - - - - - - - - - -				%	lb N/A	%
0	0	0	0	1.29	104	--
		- - - - - - UAN - - - - - -				
AA+NS/100	-	-	-	1.43	167	63
AA+NS/80	-	20 Dribble	-	1.42	152	48
AA+NS/80	-	-	20	1.45	164	60
AA+NS/60	-	40 Dribble	-	1.41	150	46
AA+NS/60	-	-	40	1.42	160	56
-	AA/100	-	-	1.44	163	60
-	AA+NS/100	-	-	1.47	163	59
-	U/100/BI	-	-	1.44	167	63
-	UAN/100/BI	-	-	1.42	163	59
-	-	40 Dribble	60	1.47	169	65
-	-	40 Spray	60	1.47	177	73
	LSD (0.10):			0.04	9	9
	CV(%):			3.0	6.7	18.

[1/] All sidedress treatments were coulter-injected midway between the rows.

[2/] AA= anhydrous ammonia, NS = N-Serve, U= urea, UAN = urea-ammonium nitrate, and BI = broadcast and incorporated.

Table 3. Corn grain yield as affected by time of N application and source of N in a strip-till system.

N Treatment				Yield		
Fall	Spring preplant	Planting	Sidedress[1/]	2001	2002	2001-02 Avg.
- - - - - - - - - - - N Source/Rate (lb N/A) [2/] - - - - - - - - - -				- - - - - - - - - - bu/A - - - - - - - - -		
0	0	0	0	91	131	111
		- - - - - UAN - - - - - -				
AA+NS/100	-	-	-	128	193	161
AA/100	-	-	-	131	193	162
-	AA/100	-	-	147	198	172
-	U/100	-	-	139	193	166
-	U/80	20 Dribble	-	156	186	171
-	-	-	100	141	204	172
-	-	20 Dribble	80	159	189	174
-	-	20 Coulter	80	145	197	171
-	-	40 Dribble	60	141	182	161
-	-	40 Coulter	60	147	182	165
-	-	40 Spray	60	156	200	178
	LSD(0.10):			15	14	10
	CV(%)			9.1	6.4	7.6

[1/] All sidedress treatments were coulter-injected midway between the rows.

[2/] AA= anhydrous ammonia, NS = N-Serve, U= urea, UAN = urea-ammonium nitrate, and BI = broadcast and incorporated.

Table 4. Two-year average grain N concentration, total N uptake at physiological maturity, and apparent fertilizer N recovery as affected by time of N application and source of N in a strip-till system.

N Treatment				Grain N	Total N	Apparent
Fall	Spring preplant	Planting	Sidedress[1/]	Conc.	Uptake	N Recov.
- - - - - - - - - - -N Source/Rate (lb N/A) [2/] - - - - - - - - - - -				%	lb N/A	%
0	0	0	0	1.27	95	--
		- - - - - - UAN - - - - - -				
AA+NS/100	-	-	-	1.37	153	58
AA/100	-	-	-	1.39	151	56
	AA/100	-	-	1.42	163	68
	U/100	-	-	1.40	157	62
	U/80	20 Dribble	-	1.41	160	65
-	-	-	100	1.45	170	75
-	-	20 Dribble	80	1.43	168	73
-	-	20 Coulter	80	1.45	172	77
-	-	40 Dribble	60	1.39	154	59
-	-	40 Coulter	60	1.43	159	64
-	-	40 Spray	60	1.43	170	75
	LSD (0.10):			0.04	10	10
	CV(%):			3.1	7.7	19.

[1/] All sidedress treatments were coulter-injected midway between the rows.

[2/] AA= anhydrous ammonia, NS = N-Serve, U= urea, UAN = urea-ammonium nitrate, and BI = broadcast and incorporated.