Comparison of Exactrix and Conventional Fertilizer Application in Corn

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Introduction

The cost of nitrogen fertilizer increased dramatically in 2008 compared to previous years. As a result, producers began looking for ways to increase their nitrogen use efficiency. One product being promoted was an Exactrix system that injects anhydrous ammonia (NH_3) as a liquid. The manufacturer of the Exactrix system claimed that nitrogen (N) rates could be reduced by as much as 30 to 40% while increasing corn yield up to10**%.**

The Exactrix system applies NH_3 with ammonium polyphosphate (APP) (ie. 10-34-0), and ammonium thiosulfate (ATS) (ie. 12-0-0-26S), through two tubes mounted on injection knives. The APP/ATS is injected first and liquid NH_3 is combined forming a crystalline material called triammonium polyphosphate sulfate (TAPPS). The manufacturer states the TAPPS formulation remains stable for 6 to 8 weeks. In 2008, a two year study was initiated to compare the yield response of corn to three N rates applied with the Exactrix system and a conventional method of application**.**

Methods and Materials

In 2008, the study was located on the Bruce Bridges farm just north of Springlake, TX. The previous crop was corn and the field was disked once during the winter followed by strip-tilling. In 2009, the study was located on the Matt Gilbreath farm southeast of Dimmitt, TX. The previous crop was grain sorghum and the field was strip-tilled prior to fertilizer application. Each field was a 60 acre half circle with the test area occupying approximately 8 acres.

One month prior to fertilizer treatment application each test area site was thoroughly sampled for soil profile nutrients. Eighteen 4-ft core samples were collected in a grid pattern. These core samples were subdivided into five subsamples based on soil depth: 0-0.5 ft, 0.5-1 ft, 1-2 ft, 2-3 ft, and 3-4 ft. Soil samples were analyzed for nutrient content at the Texas AgriLife Extension Soil, Water and Forage Testing Laboratory in College Station, TX. A routine analysis of major nutrients including pH and conductivity was completed for the 0-.5 ft sample. All other samples were analyzed for nitrate nitrogen (NO_3) only.

In order to determine the rate of N fertilizer to apply, a yield goal of 260 bu/ac was set and it was assumed that 1.1 lb N was needed per bushel. In 2008, residual N was credited at 97 lb/ac in the 4-ft soil profile. Only 50% and 25% of the residual N at that 2-3 ft depth, and 3-4 ft soil depth, respectively, was credited as usable N (Table 1). Based on these assumptions it was calculated

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that 189 lbs N/ac was needed to obtain a 260 bu/ac yield (260 bu/ac x 1.1 lb N/bu – 97 lb residual N = 189 lb N). The decision was made to bracket the amount of N actually needed with our two highest N rates in order to insure that N was not limiting. Selected N rates were 80, 160, and 240 lb/ac N. In 2009, based on 2008 results, it was decided to leave the N rates the same even though residual N was less (55 lb/ac) (Table 1).

Table 1. Average nitrate content of eighteen 4-ft soil cores collected prior to fertilizer application.

	Soil Depth (feet)					
	0-0.5	**0.5-1**	**1-2**	**2-3**	**3-4**	**Total**
	---------------------------------------lb/ac nitrate---------------------------------------					
2008	27	16	35	28	20	126
2009	15	7	12	12	9	55

The Exactrix and conventional application systems were compared at 80, 160, and 240 lb/ac N along with an untreated check for a total of 7 treatments. Each treatment was replicated four times in a randomized block design on plots measuring twelve 30 inch-rows by 400-ft or approximately 0.25 acres. Data were analyzed as a split plot with fertilizer application method (Exactrix vs conventional) as the main plot and the three N rates as subplots. The Exactrix treatments were applied by a commercial applicator. A uniform rate of phosphorus, sulfur, and zinc was applied to all plots which included 67 lbs P_2O_5 (APP or 10-34-0) + 37 lbs S (ATS or 12-0-0-26S) + 1.3 qt Zn per acre. Anhydrous ammonia was the nitrogen source used with the Exactrix system and UAN (32-0-0) was applied in the conventional system. In the conventional system, the fertilizer treatments were applied with the above P, S, and Zn mix + UAN with fertilizer knives. With both application methods, fertilizer was injected approximately 8 inches into the middle of the strip-tilled area (30-inch centers).

In 2008, all fertilizer treatments were applied on April 7th or 8th. Pioneer 33B54 was planted on May 5th at a seeding rate of 34,000 sd/ac. Irrigation water applied during the season was 20 inches. All plots were harvested on October 23rd with a commercial combine and yield calculated with the use of a weigh wagon. Some hail damage occurred to the corn and may have contributed to lower yields as well as some observed lodging in the plots. In 2009, fertilizer treatments were applied on April 23rd. Midwest 80403 corn hybrid was planted May 12th at a seeding rate of 38,000 seed/ac. Irrigation water applied during the season was 17 inches and rainfall totaled 11 inches. All plots were harvested on October 4th with a commercial combine and yield calculated with the use of a weigh wagon.

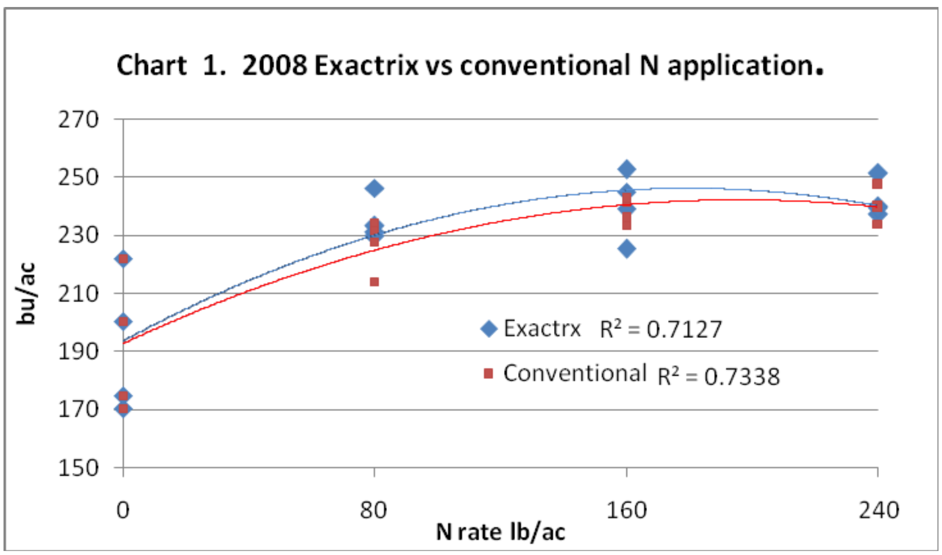
Results

There was no significant (P=0.05) yield difference between the conventional and Exactrix application methods when averaged across N rates in 2008 or 2009 (Table 2).

Table 2. Exactrix vs. conventional fertilizer application.

Application Method	2008	2009
	---------------Average Yield, bu/ac---------------	
Exactrix	239	240
Conventional	235	238

In 2008, yields for the 80 and 160 lb N rates were 8 and 2 bu/ac higher with the Exactrix application compared the conventional application, respectively (Chart 1). However these differences were not statistically significant. In 2009, there was clearly no difference in application methods at any of the N rates (Chart 2).



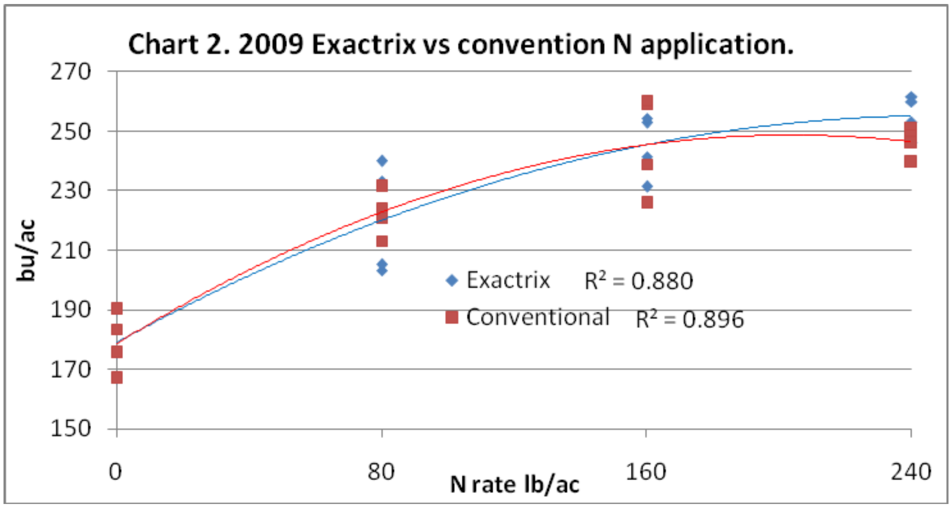


Chart 2. 2009 Exactrix vs convention N application.

In both years, yield was decreased when N rate was reduced but not as much as expected (Table 3 and 4). When N rate was decreased from 160 to 80 lb/ac, yield decreased only 8 and 5 bu/ac in 2008 and 2009, respectively. There was no advantage in increasing N rate above 160 lb/ac.

Table 3. 2008 after harvest nitrate levels in the soil profile.

	Yield	**0-0.5 ft**	**0.5-1 ft**	**1-2 ft**	**2-3 ft**	**3-4 ft**	**Total**
APPLICATION	bu/ac	lb/ac, nitrate-nitrogen					
METHOD Exactrix	239	19.8	12.0	19.3	14.5	17.9	83.2
Conventional	235	16.6	11.1	15.0	16.5	26.4	85.7
FERTILIZER RATE							
80 LBS	231 a	17.1	11.4	14.8	12.1 a	10.7 a	65.7 a
160 LBS	239 b	17.9	12.0	16.6	9.8 a	15.9 a	72.1 a
240 LBS	241 b	19.7	11.3	20.0	24.6 b	40.0 b	115.5 b
Untreated	192	16.6	8.6	9.1	8.9	4.1	47.3

[1] Numbers followed by a different letter differ significantly at LSD P = 0.05.

Table 4. 2009 after harvest nitrate levels in the soil profile.

APPLICATION	Yield	0-0.5 ft	0.5-1 ft	1-2 ft	2-3 ft	3-4 ft	Total
METHOD	bu/ac	lb/ac, nitrate-nitrogen					
Exactrix	240.1	5.6	5.2	7.6	7.3	7.8	33.5
Conventional	238.3	7.0	5.7	9.1	7.4	7.9	37.0
FERTILIZER RATE							
80 LBS	221.4 a	5.2	4.7	6.3	6.7	5.7	28.7
160 LBS	245.5 b	7.4	6.4	11.0	8.5	9.2	42.5
240 LBS	250.7 b	6.3	5.2	7.7	6.8	8.6	34.5
Untreated	179.1	3.7	4.1	7.2	4.7	5.3	25.0

[1] Numbers followed by a different letter differ significantly at LSD P = 0.05.

When 4-ft soil samples were collected and analyzed for nitrate nitrogen following harvest, there was no difference in total residual N between the conventional and Exactrix methods of application (Tables 3 and 4). In 2008, when averaged across N rates, total residual N was approximately 84 lbs/ac, and in 2009, residual N was approximately 35 lb/ac with both methods of application. This would indicate that method of application did not make any difference in N use efficiency. When nitrate levels were examined at different soil profile depths, again no differences were found between methods of application.

Fertilizer rate only affected residual N in 2008, and then only at the deeper soil levels (2-3 ft and 3-4 ft) and only in the 240 lb N/ac treatment. There was no effect of fertilizer rate on residual N at any of the soil depths measured in 2009. The difference in the two years was likely because of the higher initial residual N present prior to fertilizer application in 2008 (126 lbs) compared to 2009 (55 lbs). In 2008, there was simply more nitrogen present than what was needed by the crop after 240 lbs N were applied, resulting in more unused N deeper in the soil profile. When comparing the two years, it is interesting to note that more total residual N was present after harvest in 2008 compared to 2009 at all fertilizer rates. Even where no N fertilizer was applied (untreated), residual N was higher in 2008 at 47 lb/ac compared to 25 lb/ac in 2009.

One of the assumptions made prior to initiating the study was that residual N at the 2-3 ft and 3-4 ft soil depths should only be credited at 50% and 25%, respectively, when determining N fertilizer requirement. In both years, when the residual N in the untreated treatments was compared prior to planting and after harvest, it was determined that considerable amounts of N was used by the corn at both the 2-3 ft and 3-4 ft depths (Tables 1, 3, 4). Based on these results preplant N as deep as 4-ft in the soil profile should be credited at 100% when determining N fertilizer requirement.

Yields in the low N rate (80 lbs/ac) and untreated treatments were higher than expected both years given the amount of residual N measured prior to fertilizer application. Although we did not measure crude protein in the grain we can assume it was likely at least 9%. Since crude protein contains 16% N, we can estimate how much N was in the harvested grain in the untreated treatments each year:

2008 192 bu x 56 lb/ac x 9% protein x 16% N = 155 lbs N

2009 179 bu x 56 lb/ac x 9% protein x 16% N = 144 lbs N

Clearly, this is more N than can be accounted for from the residual N. There were 126 and 55 lb N/ac present in the 4-ft soil profile prior to planting in 2008 and 2009, respectively. By taking the estimated N in the grain plus the lbs of residual N prior to planting, and then subtracting out the remaining N after harvest in the 4-ft soil profile, we can derive how much N is in the grain that cannot be accounted for based off of our original 4-ft N analysis prior to planting (Table 5). In 2008, there was 76 lbs of N in the grain that is not accounted for. In 2009, there was 114 lbs of unaccounted N. There are three possible sources for the unaccounted N found in the grain. These are: 1) mineralization from organic matter and manure, 2) N in the irrigation water and rainfall, and 3) N deeper than 4-ft in the soil profile. Mineralization from organic matter is generally considered to be approximately 14 lb N/ac for every percentage point of organic matter. If we assume that the organic matter of this field was 1.5% then approximately 21 lbs of N could have been available from mineralization. Another source of mineralized N could have been from manure that had been applied in previous years. Irrigation water in the area contains approximately 0.6 lb N/ac-in of water and may have contributed 12 lbs or so of N.

These data indicate that in addition to residual nitrate measured by soil testing, there can be release of substantial amounts of soil N through organic matter decomposition. Thus, crediting soil test N to 4 feet should be a conservative estimate of the total amount of non-fertilizer N that will be available to the crop during the growing season.

Table 5. Unaccounted nitrogen based on yield from the untreated treatments, and from residual N prior to planting and after harvest.

Year	**Lbs Nitrogen in Grain, 9% Cr. Protein**	**Lbs Residual Soil N after Harvest**	**Lbs Residual Soil N prior to Planting**	**Lbs Unaccounted Nitrogen**
	A	**B**	**C**	**D**
	A + B – C = D			
2008	155	47	126	76
2009	144	25	55	114

Summary

The Exactrix application method did not increase corn yield over conventional fertilizer application at any of the N rates tested in this study. Further, there was no indication that N use efficiency was improved with the Exactrix system, such that fertilizer N rates could be reduced when compared to conventional application methods and products. Four-foot soil samples collected before planting and after harvest suggest that N was used as deep as 4-ft in the profile.