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Evaluation of Products Designed to Improve Nitrogen Efficiencies in Corn and Winter Wheat

Overall Summary

Studies were conducted in both winter wheat and corn in 2007. The objective of the winter wheat studies was to compare some of the new fertilizer nitrogen (N) technologies to normal grower practices and determine if these technologies could provide greater yields by providing greater N efficiencies. Applying N to corn in split applications with most of the N being applied at sidedressing is the standard practice used my most corn growers in this region. Therefore, the main objective of the corn studies was to compare these new fertilizer N technologies to sidedress-applied UAN fertilizer that is applied in a dribble band. The fertilizer technologies being tested in both the winter wheat and corn studies were ESN[1], Agrotain[2], Agrotain Plus[3], and Nutrisphere-N[4]. The winter wheat studies were conducted at two locations. At Site 1, there were only two treatments that were significantly better than the standard UAN treatment and these were the UAN split application treatment and the ammonium nitrate treatment. At Site 2, there were two treatments that were significantly better than the standard UAN treatment; one of these was the ammonium nitrate treatment while the other was the ESN30 treatment (30% ESN and 70% ammonium nitrate). The ESN30 treatment had a relative efficiency of 114% when compared to the standard UAN treatment; however, most of this improved efficiency appears to have been due to the ammonium nitrate. None of the other treatments were significantly different from the standard UAN treatment. For the corn studies, a study was conducted at five different locations and compared UAN, ESN, Agrotain Plus, and Nutrisphere-N. The results of these five locations show that none of these treatments yielded better than sidedressed UAN, with the exception of one site. At this one site, the ESN early application was significantly better than the sidedressed UAN; however, it is important to realize that this site suffered severe drought following the application of the sidedress treatments. It is also important to realize that all five of these sites were extremely dry. These technologies are designed to reduce N losses, so if weather conditions do not promote losses of N then it would be expected that these technologies would provide no benefit.

[1]ESN is a polymer-coated urea fertilizer marketed by Agrium Corporation.
[2]Agrotain is a urease inhibitor marketed by Agrotain International.
[3]Agrotain Plus is a urease inhibitor and nitrification inhibitor marketed by Agrotain International.
[4]Nutrisphere-N is marketed by Specialty Fertilizer Products as an N fertilizer additive.

Wheat Project for 2007:

This wheat project was conducted at two locations in Delaware during the 2007 growing season. Site 1 was on a sandy loam soil in Sussex County and was irrigated. Site 2 was located in New Castle County on a silt loam soil. There was no fall N applied to either site. Each location utilized a randomized-block design with four replications, and each treatment (i.e., plot) was 15 ft wide and 400 ft long. Grain yields were determined by using a small-plot combine to harvest the center 6.66 ft of each strip and weighing the grain in a weigh wagon.

The main fertilizer treatments were applied on March 13 at both sites (growth stage 25), while the second application for the split treatment was applied at growth stage 30 (April 6 at both sites). For the split applied treatment, 60% of the N was applied as UAN in the first application and 40% was applied in the second application. The UAN fertilizer (30-0-0) was applied at four rates (Site 1 = 80, 95, 110, and 125 lb N/acre; Site 2 = 60, 75, 90, and 105 lb N/acre) to quantify the yield response to N at each location; different N rates were used at each site because of different yield potentials.

The ESN was applied in two different mixtures. One mixture (ESN50) was a 50:50 mixture of ESN and ammonium nitrate, while the other mixture (ESN30) was a 30:70 mixture of ESN to ammonium nitrate. These mixture ratios were based on amounts of N, not amounts of fertilizer. The Agrotain, Agrotain Plus, and Nutrisphere-N were mixed with the UAN as recommended by each manufacturer; the highest recommended rate was used for the Agrotain products. All fertilizer treatments were broadcast. Site 1 was irrigated as needed by the grower with relatively small amounts of water, while Site 2 was not irrigated. Seasonal rainfall amounts recorded at the University of Delaware's Research and Education Center are shown in Figure 1, as well as the daily maximum soil temperature at a depth of two inches below the soil surface.

In mid-March there was a 2.5-inch rainfall event that occurred over a two-day period, and in mid-April there was a 3-inch rainfall event that occurred over a three-day period. These were the main two rainfall events that could have caused potential losses of N. The mid-April rainfall event did result in extremely wet soil conditions for a few days at Site 1, but it's not possible to know if N losses occurred.

The 2007 grain yields were about average (Table 1). The goal with the N rates used in this study was to compare products at some point just below the optimal N rate. Based on the yield responses to N (Figure 2), it appears that the rate selected at each site was a good rate for making comparisons among the various fertilizer products. The yield data at Site 1 show that none of the tested products were significantly different from UAN. It is interesting to note the ammonium nitrate was significantly better than all other treatments when compared at the same rate of N. At Site 2, there was only one of the various fertilizer treatments what was better than UAN and this was the ESN30. It is important to note, however, that the ammonium nitrate treatment was significantly higher than the UAN treatment, but was not significantly different from the ESN30 treatment.

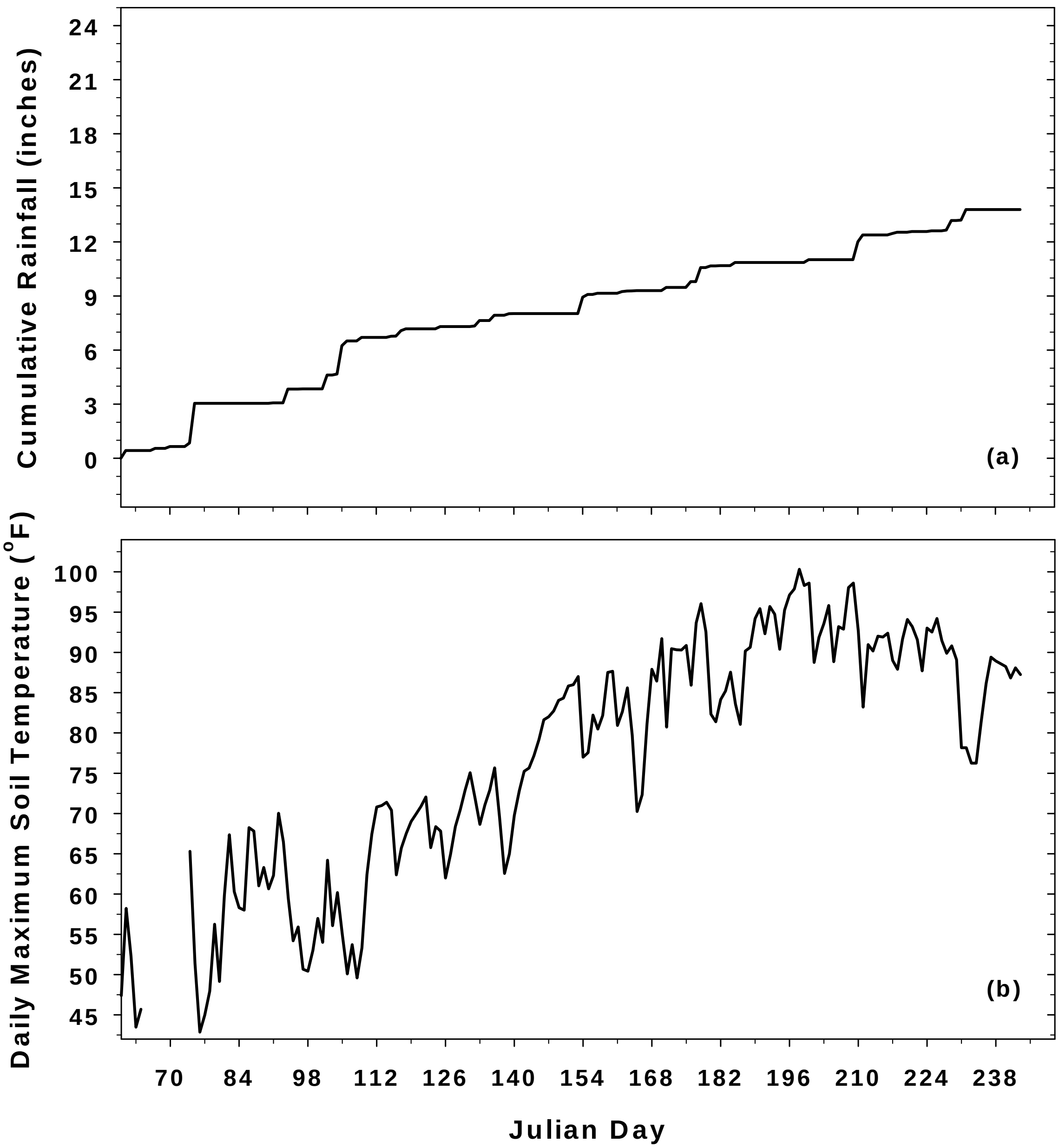

Figure 1. Cumulative rainfall (a) and daily maximum soil temperature (b) at the Research and Education Center near Georgetown, DE from March 1 to August 31, 2007.

Table 1. Grain yields of winter wheat at two Delaware sites in 2007.

Site	Trt #	Treatment[1]	N Rate	Wheat Yield	Relative Efficiency[2]
			lb/ac	bu/ac	%
1	1	ESN50	95	82.1	94
	2	ESN30	95	86.5	99
	3	UAN_AT	95	86.1	98
	4	UAN_ATP	95	85.5	98
	5	UAN_NSN	95	88.0	101
	6	UAN_split	95	94.4	108
	7	UAN	80	77.6	100
	8	UAN	95	88.0	101
	9	UAN	110	96.7	100
	10	UAN	125	97.6	92
	11	34-0-0	95	97.8	112
	$LSD_{(0.10)}$			5.3	
	CV(%)			4.8	
2	1	ESN50	75	78.3	102
	2	ESN30	75	88.0	114
	3	UAN_AT	75	78.0	101
	4	UAN_ATP	75	74.8	97
	5	UAN_NSN	75	75.8	99
	6	UAN_split	75	74.3	97
	7	UAN	60	70.5	100
	8	UAN	75	76.1	99
	9	UAN	90	84.4	101
	10	UAN	105	90.0	100
	11	34-0-0	75	85.5	111
	$LSD_{(0.10)}$			6.6	
	CV(%)			6.9	

[1]**ESN50** = 50/50 mix of ESN and ammonium nitrate; **ESN30** = mixture that is 30% ESN and 70% ammonium nitrate; **UAN_AT**=30-0-0 with Agrotain added; **UAN_ATP**=30-0-0 with Agrotain Plus added; **UAN_NSN**=30-0-0 with Nutrisphere-N added; **UAN_split**=30-0-0 split appled with 60% at growth stage 25 and 40% at growth stage 30; **UAN**=30-0-0; **34-0-0**=ammonium nitrate.

[2]Relative to UAN (30-0-0); calculated from regression equations shown in Figure 2.

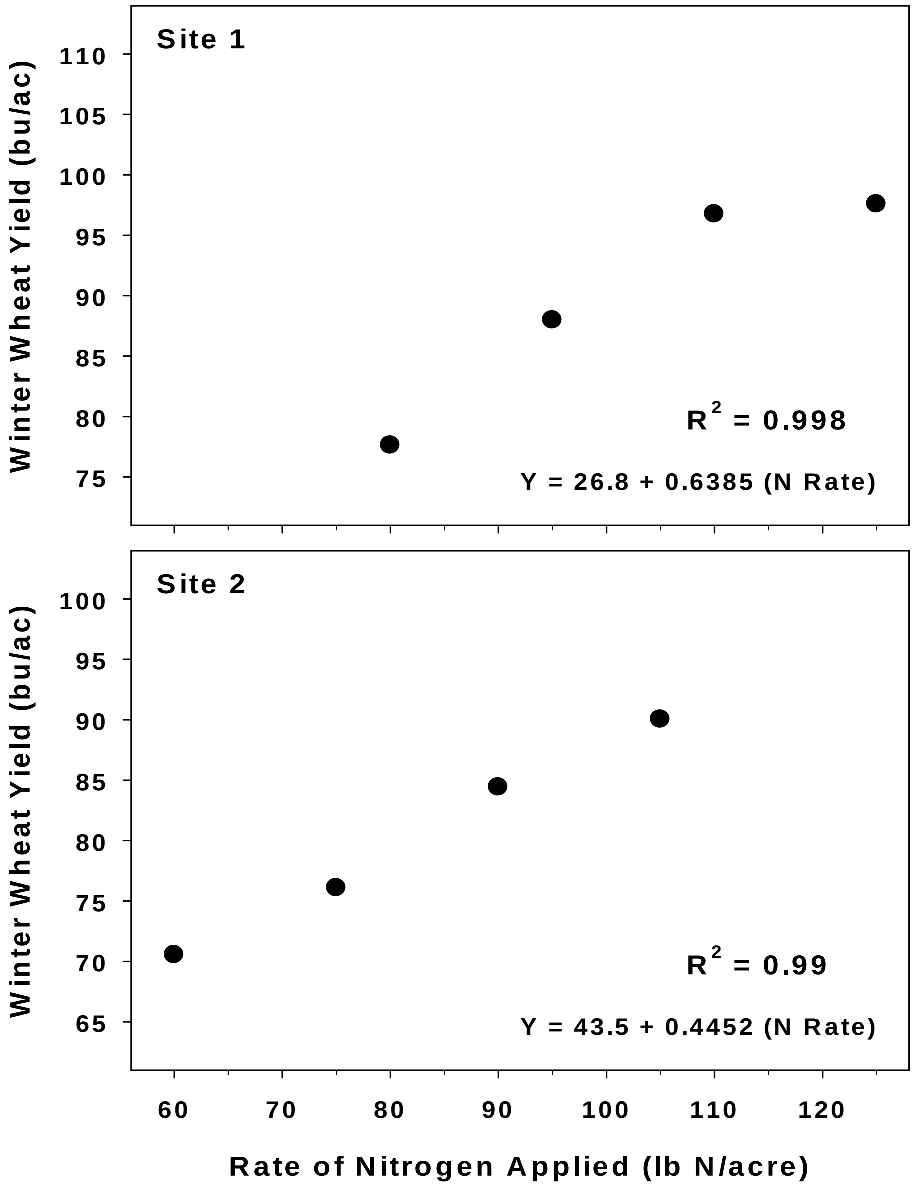

Figure 2. Grain yields of winter wheat for four N rates. The slope of the linear equation was significantly different from zero for both sites. The equation for Site 1 does not include the highest rate of N (i.e., the highest rate was not significantly different from the previous rate).

The relative efficiencies that are shown in the last column of Table 1 were calculated by using the regression equations shown in Figure 2 to calculate the predicted yield based on the rate of N that was applied as regular UAN. This predicted yield was then converted to a percentage of the observed yield. Therefore, a relative efficiency of 100% means that the observed yield was exactly the same as the yield predicted from the regression equation for each site. At Site 1, the UAN_split treatment was 8% better than a single application of UAN, while the ammonium nitrate was 12% better. At Site 2, the ESN30 treatment was 14% better than the UAN treatment at the same rate of N, however, the ammonium nitrate treatment was 11% better than the UAN treatment. This suggests that most of the ESN30 yield increase came from the ammonium nitrate, since 70% of the N in this treatment was from ammonium nitrate.

Corn Project in 2007:

This corn project in 2007 was conducted at five different locations around Delaware and Maryland (Table 2). None of the five sites were irrigated. All sites were planted by the cooperating growers, and except for Site 3, some N was applied with the planter as starter fertilizer. Also, at Site 4, an additional 40 lb N/acre was applied as UAN with the pre-emergence herbicide. The 16 fertilizer treatments (Table3) were applied by the University of Delaware and the sidedress treatments were applied when the corn was between 8 to 12 inches tall.

Table 2. Site descriptions for the five sites in Delaware and Maryland.

Site	Soil Type	Tillage[1]	Planting Date	Hybrid	Previous Crop[2]	Starter Fertilizer[3]
						lb/ac
1	Silt Loam	NT	30-Apr	N65C5	W/DS	51-41-0
2	Silt Loam	CT	2-May	P34A16	Corn	9-22-5.5
3	Silt Loam	NT	2-May	DK63-74	W/DS	None
4	Silt Loam	NT	9-May	N55C5	W/DS	20-20-0[4]
5	Silt Loam	CT	7-May	P33M57	Corn	20-50-50

[1]NT = No-Till; CT = Conventional Tillage

[2]W/DS = winter wheat followed by soybeans

[3]pounds per acre of N - P_2O_5 - K_2O

[4]40 lb N/acre was applied with the pre-emergence herbicide

Eight of the treatments were different rates (0, 30, 60, 90, 120, 150, 180, & 210 lb N/acre) of UAN (30-0-0) fertilizer applied at sidedressing as a dribble band on the soil surface between the rows of corn. The other treatments included UAN mixed with Agrotain Plus, UAN mixed with Nutrisphere-N, and ESN. For the ESN treatments, one treatment was 100% of N as ESN applied early, while the other was 50% ESN applied early and 50% of N as UAN dribbled at sidedressing. None of the ESN treatments were incorporated and were applied near the time of corn emergence. All of the fertilizer technologies were applied at two rates (90 and 120 lb N/acre). The Agrotain Plus and Nutrisphere-N treatments were dribbled in a band on the soil surface, while the ESN was broadcast.

Individual plots were 15 ft wide (six rows) and 100 ft long. Corn yields were determined by harvesting the three center rows of each plot with a plot combine equipped with on-board weigh buckets. The SAS system was used for all statistical analyses, and the quadratic-response-and-plateau model was used to describe the corn yield N rate responses at each site.

Rainfall amounts during the summer were well below normal and temperatures were about normal. Conversations with many local growers suggest that the 2007 corn growing season was one of the driest ever and many growers reported that dryland corn yields were some of the lowest ever experienced by many of these growers. During the corn pollination period, temperatures were hot and soil moisture levels were greatly reduced so that most fields were experiencing stress during this time.

Corn grain yields were below average at all sites due to drought during grain fill, and at Site 2, yields were greatly reduced (Table 3). At all sites except Site 2, there was a significant grain yield response to the application of N fertilizer. There was no statistically significant difference between the 90 and 120 lb N/acre rates of fertilizer at any of the sites. Therefore, all contrasts comparing the fertilizer treatments were based on the average of these two N rates. When comparing the various fertilizer technologies to UAN, none of the technologies were significantly different from applying UAN in a dribble band. Applying UAN in a dribble band is the most common method of applying N during corn production in this region. The only comparison that showed a significantly ($P<0.10$) greater yield than UAN was ESN preplant at Site 2. This difference could be explained by the lack of rain received after the sidedress treatments were applied at this location. With the lack of rain, the availability of the sidedress treatments was likely delayed. Whereas, the N from the ESN preplant treatments may have been further down into the soil because it was applied earlier. This response would not be expected in most years, however, because excess rainfall is normally more of a problem than lack of rainfall during late spring in this region. Figure 3 shows the yields observed with the eight different rates of sidedressed UAN and the QRP model, while Figure 4 shows the yields of the various fertilizer technologies relative to the QRP modeled yields of the UAN sidedress treatments. When evaluating these data, it's important to remember that there were few, if any, opportunities for N losses during the season, especially for the sidedress treatments. Future studies are needed to evaluate these products under weather conditions where N losses are likely.

Table 3. Corn grain yields for various N treatments at five Delaware sites in 2007.

Early Fertilizer Source	Sidedress Fertilizer Source	Pre-Emerge N Rate	Sidedress N Rate	Total N	Corn Grain Yield Site 1	Site 2	Site 3	Site 4	Site 5
		-------- lb N/acre --------			---------------------- bu/ac ------------------------				
None	None	0	0	0	121	91	117	91	104
None	UAN	0	30	30	130	94	147	106	126
None	UAN	0	60	60	179	105	136	113	138
None	UAN	0	90	90	161	90	159	150	154
None	UAN	0	120	120	164	97	160	152	149
None	UAN	0	150	150	173	97	164	162	161
None	UAN	0	180	180	164	95	171	164	182
None	UAN	0	210	210	177	86	181	148	180
None	Agrotain Plus	0	90	90	168	98	152	145	163
None	Agrotain Plus	0	120	120	156	98	165	147	158
None	Nutrisphere-N	0	90	90	177	99	154	144	166
None	Nutrisphere-N	0	120	120	150	96	148	162	154
ESN	None	90	0	90	164	112	160	137	159
ESN	None	120	0	120	159	104	163	158	153
ESN	UAN	45	45	90	158	99	170	154	154
ESN	UAN	60	60	120	160	106	159	154	155

Contrasts	P > F Site 1	Site 2	Site 3	Site 4	Site 5
Control vs. All N	0.0021	0.6187	0.0005	0.0001	0.0001
UAN vs. ESN pre	0.9252	0.0618	0.8350	0.5615	0.5579
UAN vs. ESN split	0.7280	0.2399	0.7396	0.6826	0.6310
UAN vs. ATP	0.9971	0.5511	0.9421	0.5138	0.1828
UAN vs. NSN	0.9344	0.5878	0.4683	0.8857	0.1656

Parameters for the QRP Model for UAN Response	Site 1	Site 2	Site 3	Site 4	Site 5
Intercept	115.4	90.8	123.0	85.8	106.0
Linear	1.195	0.134	0.387	0.812	0.529
Quadratic	-0.00668	-0.00112	-0.00060	-0.00227	-0.00081
Plateau	168.9	94.9	185.5	158.6	192.1
N Max	89.5	60.2	323.3	179.2	325.4
Ec Opt[1]	82.0	15.3	239.7	157.2	263.9

[1]Economic optimum based on $5/bushel of corn and $0.50/lb of N fertilizer

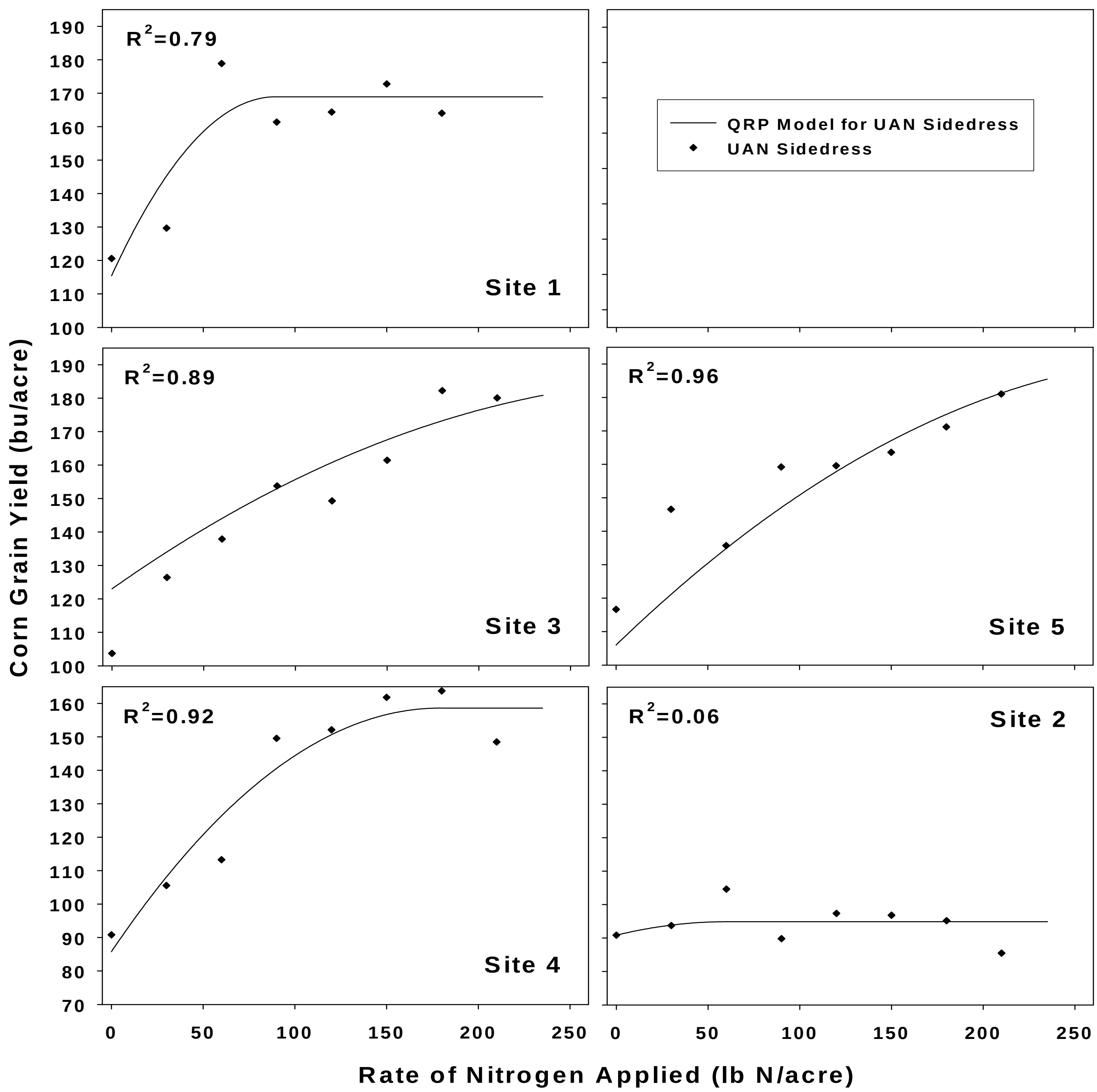

Figure 3. Grain yields observed for each rate of sidedress UAN applied at five sites in Delaware in 2007. The curve and R-square values are for the quadratic-response-and-plateau (QRP) model.

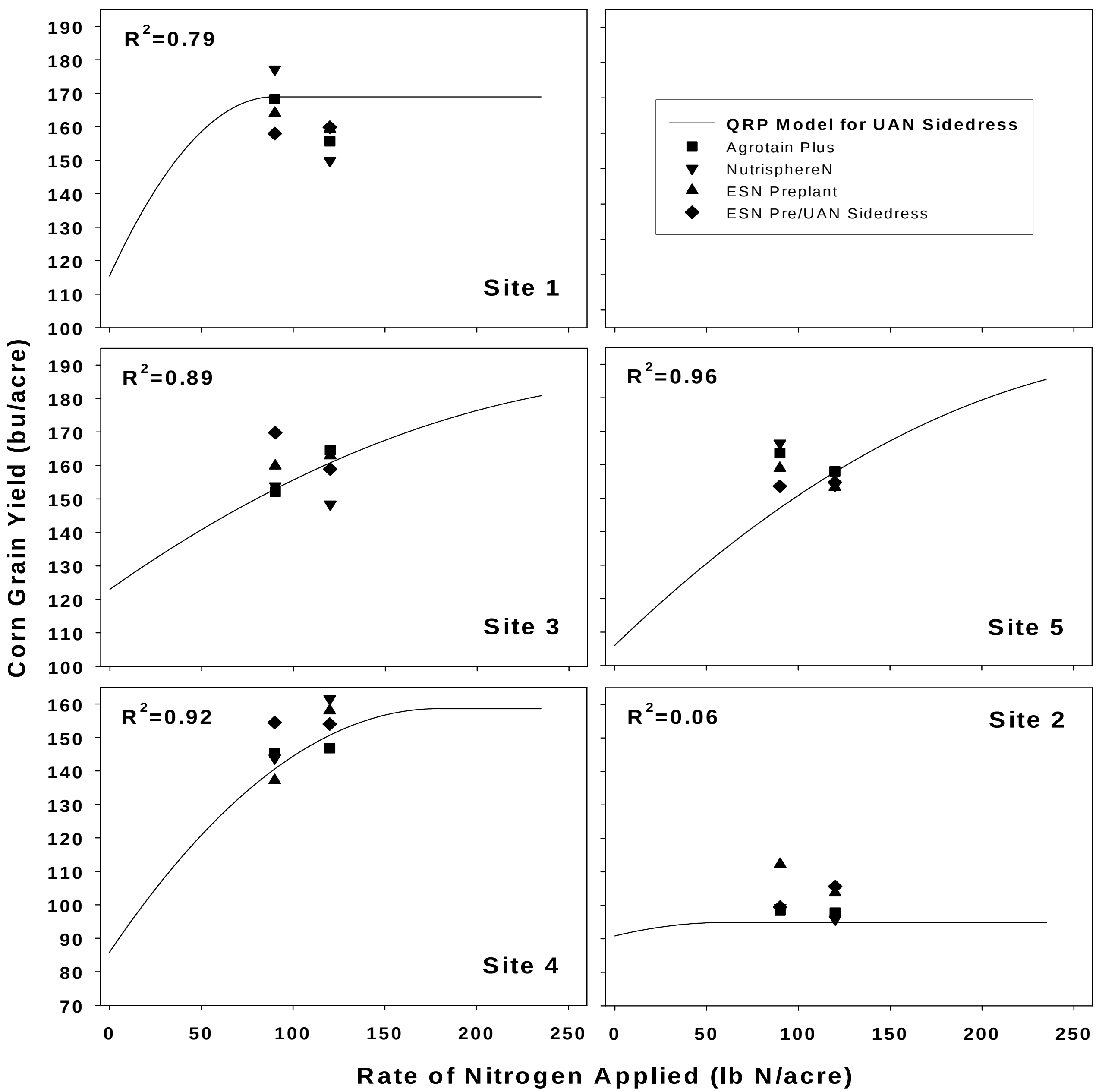

Figure 4. Grain yields observed for two rates and four different types of N fertilization at five sites in Delaware in 2007. The curve and R-square values are for the quadratic-response-and-plateau (QRP) model of grain yield versus rate of sidedressed UAN (i.e., from the yield data shown in Figure 3).