Nitrogen dynamics of standard and enhanced urea in corn

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INTRODUCTION:

Concerns about illegal uses of anhydrous ammonia and ammonium nitrate may make urea a preferred N fertilizer choice in the future. Urea is more concentrated than most N sources and thus may be more economical to apply. However, urea is subject to volatilization losses that in extreme circumstances can be as much as 50% (Harrison and Webb, 2001). To combat N losses from urea, manufacturers have developed additives and specialty N fertilizer products designed to inhibit N losses and prolong the N release period. These characteristics may reduce leaching and nitrate runoff, and may reduce emissions of N-containing greenhouse gases. Further, they may offer producers some flexibility in their N management decisions.

OBJECTIVE:

The overall goal of this project was to evaluate different Urea-N management products on the fate of fertilizer N and corn yields.

The specific objectives were:

1) Evaluate corn yield response to fertilization with standard urea and enhanced N-urea products.
2) Examine timing and quantity of corn fertilizer N uptake, fertilizer N use efficiency, and recovery in the soil base for these product classes using ^{15}N tracer techniques.

Procedures: The experiment was arranged as a randomized complete block design with four replications and repeated in 2009, 2010, and 2011. All years, corn (Pioneer 33M16) was sown in 30” rows in no-till plots previously planted in soybean at Bradford Research and Extension Center (Mexico silt loam) in plots 20’ x 100’ (2009) and 30’x 100’ (2010, 2011). In 2009 seven treatments were applied (Nutrisphere-treated urea, Agrotain-treated urea, urea, ESN urea, Duration PCU urea, 32% UAN, no-fertilizer N) and in 2010 and 2011, an additional treatment, SuperU, was applied. All nitrogen treatments were applied at 150 lbs N acre^{-1}. All urea treatments were applied at planting and UAN treatments were applied post plant. Agrotain and Nutrisphere were applied to pre-weiged urea using a small concrete mixer at rates according to manufacturer’s suggestions.

To determine in-season plant growth one meter-row of plants in each plot was harvested five times in each growing season and separated into leaves, stems, and reproductive parts and dried at 60°C for 96 hrs and weighed. Growth stage was determined within each plot when biomass was assayed. Plant N status was determined by gas-fusion with a LECO TruSpec N nitrogen determinator from plant parts used for growth analysis. Soil N status was determined at three depths (0-5, 5-15, and 15-25 cm) four times each season by compositing five samples taken from within each plot. Samples were extracted with 2M KCl and extracts were analyzed for nitrate and ammonia N by flow injection analysis with a Lachat QuikChem 8500 FIA system. Nitrogen fate was determined by ^{15}N labeling from microplots (2 x 2 m) established in each plot fertilized with agrotain-treated urea, PCU, and untreated urea. Microplots were covered during the application of fertilizer treatments at planting and subsequently fertilized with ^{15}N labeled urea either treated with Agrotain, a polymer coating, or left untreated. Leaf discs (9.6 mm) were taken from each leaf from five plants in each microplot and dried and soil samples from the microplots were taken when aforementioned soil sampling occurred. Leaf tissue and soil samples from microplots are being analyzed at the University of California-Davis Stable Isotope Facility.

Corn yields were determined by harvesting two rows (2009) and four rows (2010, 2011) from each plot using a small plot combine and correcting grain moisture content to 15.5%. All data were analyzed with Statistical Analysis Software (SAS) using PROC MIXED. Soil sampling data, growth (biomass) data, and developmental stage (vegetative) data were further analyzed as repeated measures. Pair-wise mean comparisons using Tukey's Honest Significant Test at an alpha of 0.05 were used to determine treatment differences. Grain yield differed between years so each year was analyzed and presented separately. Soil sampling data and growth (biomass) data were similar in 2010 and 2011 so data were combined across these years. Developmental stage data from 2011 was incomplete due to hail damage so only 2009 and 2010 data are presented. Data for tissue nitrogen, ^{15}N, and 2010 and 2011 soil N are still being analyzed and are not available for this report.

Results: Corn yield differed between years and between urea enhancement products and N source in most years (Table 1). In 2009, yields were good compared to yields that are typical at the Bradford Research and Extension Center (BREC) and yields in 2010 were low in comparison. In 2011, yields were generally considered poor across all research plots at BREC and this is mostly attributed to unseasonably cool and wet weather during the month of May. This was followed by a hail storm on July 5 and severe drought through most of the remaining season. Considering all years, the only broadcast-applied urea N treatments that resulted in yields that were greater than the untreated urea control were Duration PCU in 2009, Duration PCU, ESN, and SuperU in 2010, and Duration PCU and ESN in 2011. As a grower's standard, UAN is used as treatment to compare these products to a typical N treatment. It is soil-injected so its comparison to the urea treatments is considered for check treatment purposes only. Further, Duration PCU is a polymer coated urea that is currently not marketed for agricultural use and is designed for use in turf and ornamental markets and on golf course turf. Its use in this study was to compare a "true" polymer coated urea to the other urea enhancement products. As for agriculture use products, ESN (2010, 2011) and SuperU (2010) were the only products that resulted in corn yields that were greater than untreated urea.

Soil sampling data for 2009 (Fig. 1) illustrate some of the N dynamics associated with the different treatments. Agrotain, Nutrisphere, and untreated urea appear similar in their soil N dynamics in that the highest nitrate levels were found at the June 9 sampling date. This response is reasonable considering that these products resulted in similar grain yields in 2009. ESN and Duration PCU resulted in nitrate levels that were highest at the third sampling date. This result corresponds to their slow-release characteristics that delayed N release. Nonetheless, only Duration PCU resulted in yields that were greater than the untreated control in 2009.

Biomass growth during the 2009 growing season (Fig. 2) differed from that in 2010 and 2011 (Fig. 3). By June 6th, growth in Agrotain-, Nutrisphere-, and ESN-treated corn appears greater than that in PCU- and UAN-treated corn. This suggests that N release was greater in the aforementioned products during the first few weeks of growth resulting in the greater biomass. However, by the end of the season, biomass accumulation appears greater in the UAN and PCU treatments and this corresponds with yield results from 2009. In 2010 and 2011 (Fig.3), biomass yields reached their peak early in the growing seasons for ESN, SuperU, Agrotain, and untreated urea and little biomass accumulation occurred after the July 9 sampling date. Meanwhile, UAN and PCU biomass accumulation peaked in late July. These results from 2010 and 2011 are difficult to interpret as the corresponding yields did not always follow these trends each year. Hail damage did not allow for an accurate estimate of vegetative development in 2011 so only data for 2009 and 2010 (Fig. 4) is shown. For each treatment, development occurred sooner in 2009 than 2010 and this is reflected in grain yields. Nonetheless, differences between treatments did not correspond well with yields.

Conclusions: In this research, ESN improved yields in two of three years relative to untreated urea, and SuperU improved yields in one of three years. Other agriculture-use products evaluated did not improve yields relative to untreated urea. Results were year-dependent and neither ESN nor SuperU consistently improved yields. Yield responses to these treatments were inconsistent and yield responses across years were inconsistent and highlight the effect of environment on the activity of these nitrogen products. Yield responses in 2009 across all treatments were consistent with yields of other non-related research at BREC. However, yield responses in 2010 were inconsistent across treatments. Yield responses in 2011 were consistent with other research at BREC. Because of cool, wet conditions in May, a destructive hail storm in early July, and then severe drought throughout much of the remaining season, 2011 yields were considerably lower than normal across BREC.

Table 1. Corn yield response to various urea enhancement products.

	Year		
Treatment[a]	2009	2010	2011
	------------------- *Yield (bu/ac)*[b]	--------------------	
Duration PCU	171.9 A	112.1 BC	77.4 A
UAN (32%)	155.1 A	143.1 A	75.5 A
ESN	138.9 AB	84.3 C	78.6 A
SuperU	-----------	120.7 AB	66.9 B
Agrotain-treated urea	137.5 B	47.1 D	71.2 AB
Nutrisphere-treated urea	124.5 B	50.3 D	65.5 B
untreated urea	129.1 B	61.2 D	57.8 B
No N treatment	47.2 C	17.6 E	28.5 C

[a] Nitrogen treatments applied at rates equivalent to 150 lbs N/ac.
[b] Means within a column followed by the same letter are not significantly different ($P<0.05$)

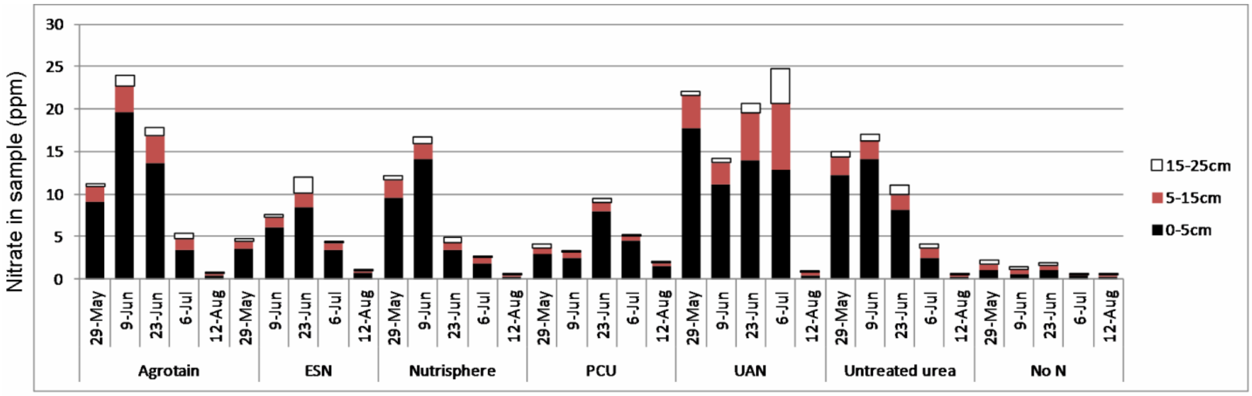

Figure 1. Soil sample nitrate at different depths and different sampling times in 2009

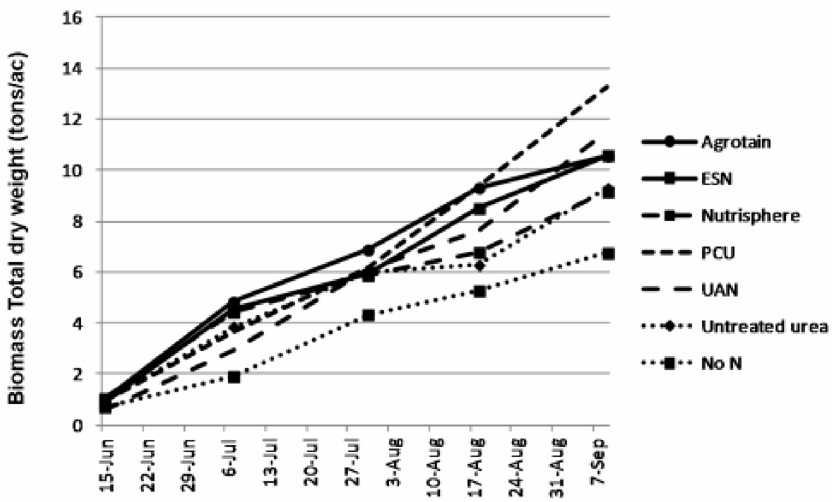

Figure 2. Biomass total dry weight of corn during the 2009 growing season.

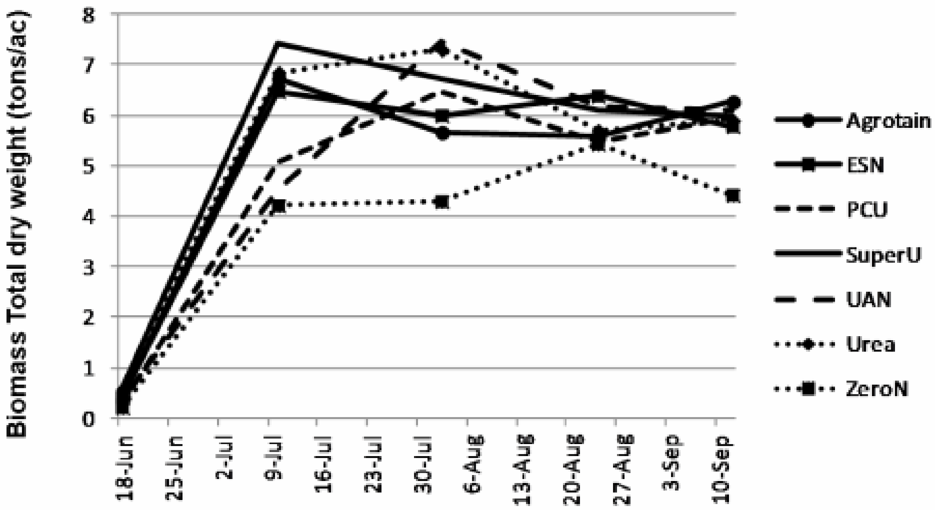

Figure 3. Biomass Total dry weight of corn during the growing season. Data from 2010 and 2011 were combined.

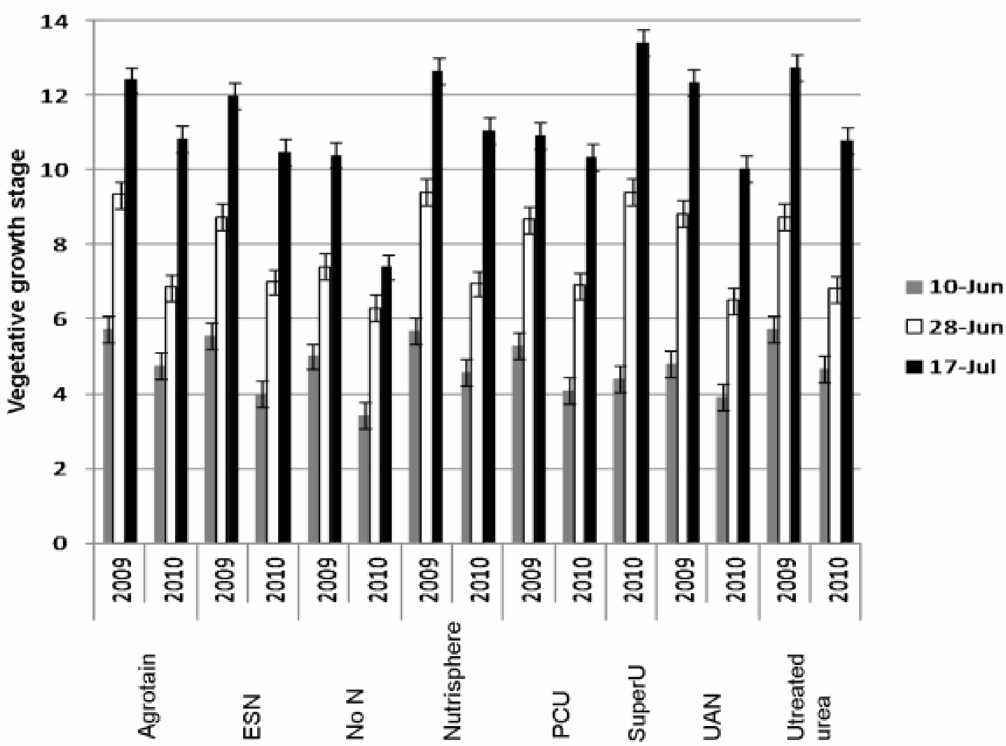

Figure 4. Vegetative growth stage of corn at three sampling dates in 2009 and 2010. Bars represent mean +/- standard error (P<0.05)