COST-EFFECTIVE N MANAGEMENT USING REDUCED RATES OF POLYMER COATED UREA IN CORN

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Introduction:

Poorly drained soils are common in Missouri. Farmers with poor drainage have additional options for N management using polymer coated urea (Merchá Paniagua et al., 2005; Schwab et al., 2005). Polymer coated urea has been shown to reduce N_2O flux in plots with poor drainage in relatively wet years (Merchá Paniagua et al., 2005). Performance of polymer coated urea has been equivalent to anhydrous ammonia in Northern Missouri (Motavalli et al., 2005) and less consistent in Central Missouri (Medeiros et al., 2005). Preliminary research in 2005 at Novelty indicated that polymer coated urea rates may be reduced up to 30% while maintaining corn grain yields similar to a 150 lb/a rate regardless of application timing. This may be a cost-effective management option for farmers to offset the cost of the polymer coating.

Availability of ammonium nitrate and anhydrous may be limited in the future. The slow-release properties of polymer coated urea have appealing characteristics for corn producers in watersheds with the potential of surface water runoff or soils with high leaching potential (Rosen and McNearney, 2005). Placement of polymer coated urea has demonstrated improved utility and yield of potato in Wisconsin (Rosen and McNearney, 2005) and corn in Minnesota (Randall, unpublished) compared to other N sources. Finally, incentive payments through the Conservation Security Program were available to producers in Missouri utilizing coated urea technology. This could impact over 1.8 million acres in qualified watersheds (NRCS, 2005). Recently, N prices have increased dramatically while corn prices have been variable. A polymer coating may increase cost of N up to $0.11/lb; therefore, reduced rates of polymer coated urea need to be evaluated to balance the additional cost of the coating while maintaining the yield potential of corn. In addition, no published research has evaluated the release of the polymer coated urea for corn in field experiments on poorly drained soils. No research has evaluated degradation as affected by residue, tillage, or placement in the soil. No published research has reported the effects of reduced rates of polymer coated urea and determined the interaction with application timing as a cost-effective method to reduce N application rates.

The objectives of this study were to: 1) evaluate yield response of no-till corn with reduced rates of polymer coated urea compared with non-coated urea at different application timings, 2) determine the interaction between application timing and N source on ammonium-N and nitrate N in the soil profile, and 3) assess the impact of application timing and placement on polymer coated urea degradation.

Materials and Methods:

A field trial with four replications was established at the Greenley Research Center in plots 10 by 40 ft to evaluate crop response to polymer coated urea (ESN) compared to non-coated urea at 0, 50, 100, and 150 lbs N/acre. 'Asgrow RX752' was no-till planted on April 28, 2006 and April 23, 2007 at 30,000 seeds/acre. In the fall, 23-60-100 and 27-70-100 was applied as recommended by the University of Missouri soil test lab in 2006 and 2007, respectively.

Nitrogen application timings included: 1) fall (November 4, 2005 and November 7, 2006), 2) early preplant (April 5, 2006 and March 16, 2007), 3) pre-emergence (April 28, 2006 and April 23, 2007), and 4) broadcast side-dress (1-2 ft corn on June 5, 2006 and May 29, 2007) treatments. An untreated and standard anhydrous treatment at 150 lbs N/acre was included as a control. The field trial was monitored for ammonium- and nitrate-N at three timings throughout the season (first rainfall after the side-dress timing, prior to silking, and harvest) and throughout the profile at three incremental depths (0-6, 7-12, 13-18 inches). The untreated control and 150 lb N/a rates of polymer coated urea, urea alone, and anhydrous treatments were monitored for N concentrations and are currently undergoing analysis.

An additional field study utilized buried bags to evaluated degradation of the polymer-coated urea to determine N release throughout the growing season. This method has been utilized in wheat research on poorly drained soils (Schwab et al., 2005) and potato research on sandy soils (Rosen and McNearney, 2005), but N release has not been evaluated on poorly-drained soils for corn planted in different residues common in Missouri. This study included a factorial arrangement of 3 residues (no-till wheat stubble with red clover, no-till soybean residue, and reduced till soybean residue), 3 application depths (surface applied, 2 inch depth, and 4 inch depth), 3 application timings (March, April, and May), and 5 removal timings (April, May, June, July, and black layer). An additional air exposed control was included in the design. Each treatment was replicated three times. A nylon window screen packet was constructed for each treatment. Each screen packet held approximately 10 grams of polymer coated urea. Packets were weighed prior to placement in the field. The packets were then recovered from each treatment, washed with ice water, dried and weighed. Release of urea was calculated as (1-(removal date weight/weight at application))*100. All data were subjected to an analysis of variance and means separated using Fisher's Protected LSD (p=0.05). An increase in returns with PCU was calculated as: [increase in average grain yield for 2006 and 2007 over urea or anhydrous ammonia *$3.50/bu corn] – [application + N cost]. Nitrogen cost was estimated for urea at $0.585/lb N, PCU at $0.635/lb N, and anhydrous ammonia at $0.415/lb N. Custom application cost was similar for urea and PCU at $4.80/acre while anhydrous ammonia was $0/acre.

Results in 2006:
Grain yields were above average at Novelty in 2006. No-till corn yield with polymer coated urea at 150 lb/a was similar to anhydrous at 150 lb/a at all four application timings while yields with anhydrous were 24 to 59 bu/acre greater than urea at the fall, early preplant, and side-dress timings (Figure 1). Rainfall following application of the pre-emergence N treatment probably contributed to grain yields that were similar among the N sources at this timing in this research. Reduced rates of polymer coated urea appear justified at later application timings when compared with urea alone. Polymer coated urea rates that were reduced by 30% had yields similar to the 150 lb/a rate at the pre-emergence and side-dress timings in 2006, and were similar to anhydrous at 150 lb/acre.

Release of nitrogen from polymer coated urea granules was greatest for deep placement followed by the 1-2 inch depth placement in no-till wheat/clover residue (Figure 3). Moisture content may be greater in this cropping system. Surface applied polymer coated urea release was ranked no-till soybean stubble > no-till wheat/clover residue = conventional tillage.

November applied polymer coated urea released 20-30% of the fertilizer by mid-April, 2006 (Figure 5). Fertilizer release was similar for nearly all of the 1-2 and 4 inch deep placements for all of the recovery dates except November applied polymer coated urea. Surface applied polymer coated urea was slower for March applied fertilizer from mid-May to mid-July, April applied fertilizer from mid-June to mid-July, and May applied fertilizer at the mid-July recovery dates. Air exposed packets were included as control treatments to determine the effect of sunlight, rainfall, and other conditions on the integrity of the polymer coating. Sunlight was probably a major factor affecting the coating and may help in the degradation of the polymer coating. In the absence of direct soil contact, release of fertilizer from the polymer coating was generally less than surface applied treatments.

Soil nitrate-N concentration was greater for anhydrous ammonia applied preplant or side-dressed than PCU or urea alone at the July and October sampling dates (Figure 7). Total ammonium-N concentration was greater when anhydrous was side-dressed than when PCU or non-coated urea were side-dress applied. Soil test nitrate- and ammonium-N concentrations with PCU were greater than or equal to non-coated urea at all application timings and soil sample dates, indicating greater N loss with urea for some application timings. Nitrate-N concentration at harvest indicated similar recovery with PCU and urea.

Results in 2007:

Grain yields were average in 2007 (Figure 2). Yield with polymer coated urea at 150 lb/a was similar to anhydrous at 150 lb/a at the fall application timing while grain yield with PCU was greater than urea at the early preplant timing at all rates and the pre-emergence timing at 100 lbs/acre. Moist soil at the time of application probably contributed to grain yield differences between urea and PCU. Similarly, moist subsoil conditions may have resulted in ammonia loss with anhydrous. Up to a 30% reduction in PCU rates had yields similar to the 150 lb/a rate at all application timings and yields greater than or equal to urea and anhydrous ammonia at all application timings.

Urea release was greatest for surface applied PCU in conventionally tilled soil followed by 1-2 inch and 4 inch placements (Figure 4). Surface applied PCU release was ranked conventional tilled soil > no-till wheat stubble > no-till soybean stubble. Differences in release in 2006 and 2007 may be related to the variation in soil temperature and moisture at the different depths for different tillage systems since spring conditions were wetter in 2007 than 2006.

PCU applied in November released less than 30% of the urea by mid-April (Figure 6). Minimal differences in urea release were observed among placement depths. Total release was nearly 90% for all application timings and placements when corn reached black layer. Air exposed packets released approximately 60% of the urea for the early application timings and 50% for late application timings.

Summary and Conclusions:

Reduced rates of polymer coated urea in no-till may be justified at early preplant, pre-emergence, and side-dress application timings when compared to urea alone. Tillage system and fertilizer placement affects the release of polymer coated urea. This may be related to the soil moisture content and temperature differences in these poorly drained soils. Limited differences in total urea release were observed in 2006 and 2007. Slower urea release was observed in 2006 when urea was surface applied compared to 1-2 and 4 inch placements. Release rates increase as PCU application timing is delayed. Polymer coated urea fertilizer release reached 70-90% by black layer while in the absence of direct contact with moist soil, fertilizer release was 50-60%. Dry conditions may limit release of urea from the polymer coating and affect N availability to the crop.

In general, yields with polymer coated urea were greater than or equal to non-coated urea in 2006 and 2007. PCU increased returns over urea alone for early preplant, pre-emergence, and side-dress application timings for all application rates except the preplant timing at 150 lbs/a when averaged over medium (2007) and high (2006) yielding years (Figure 8). PCU increased returns over anhydrous ammonia when applied at preplant and side-dress timings for no-till corn. Additional research evaluating deep placement of PCU in the fall or early preplant is needed to identify cost-effective uses of PCU when compared to anhydrous ammonia.

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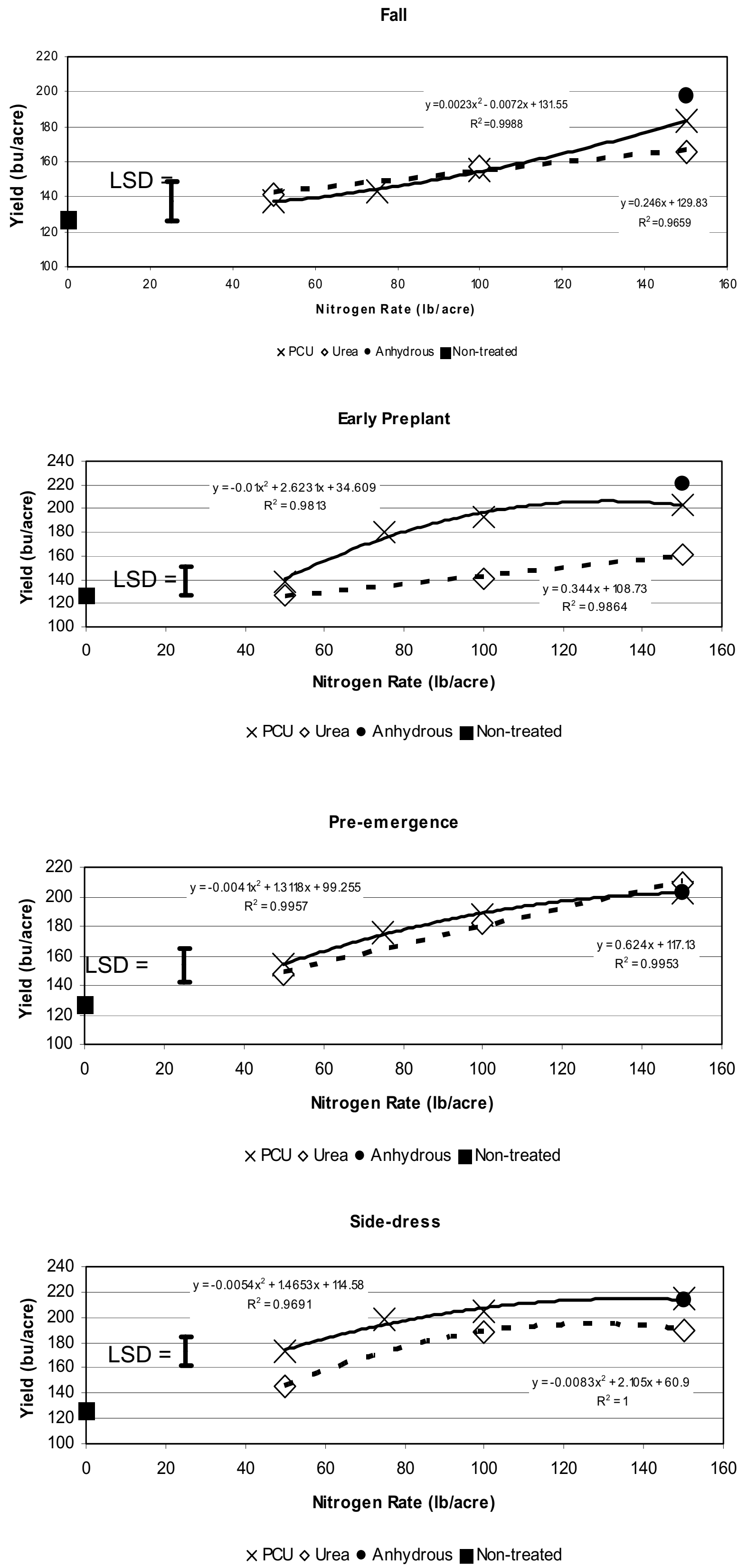

Figure 1. Yield response of no-till corn to reduced rates of polymer coated urea compared with non-coated urea at fall, early preplant, pre-emergence, and side-dress application timings in 2006.

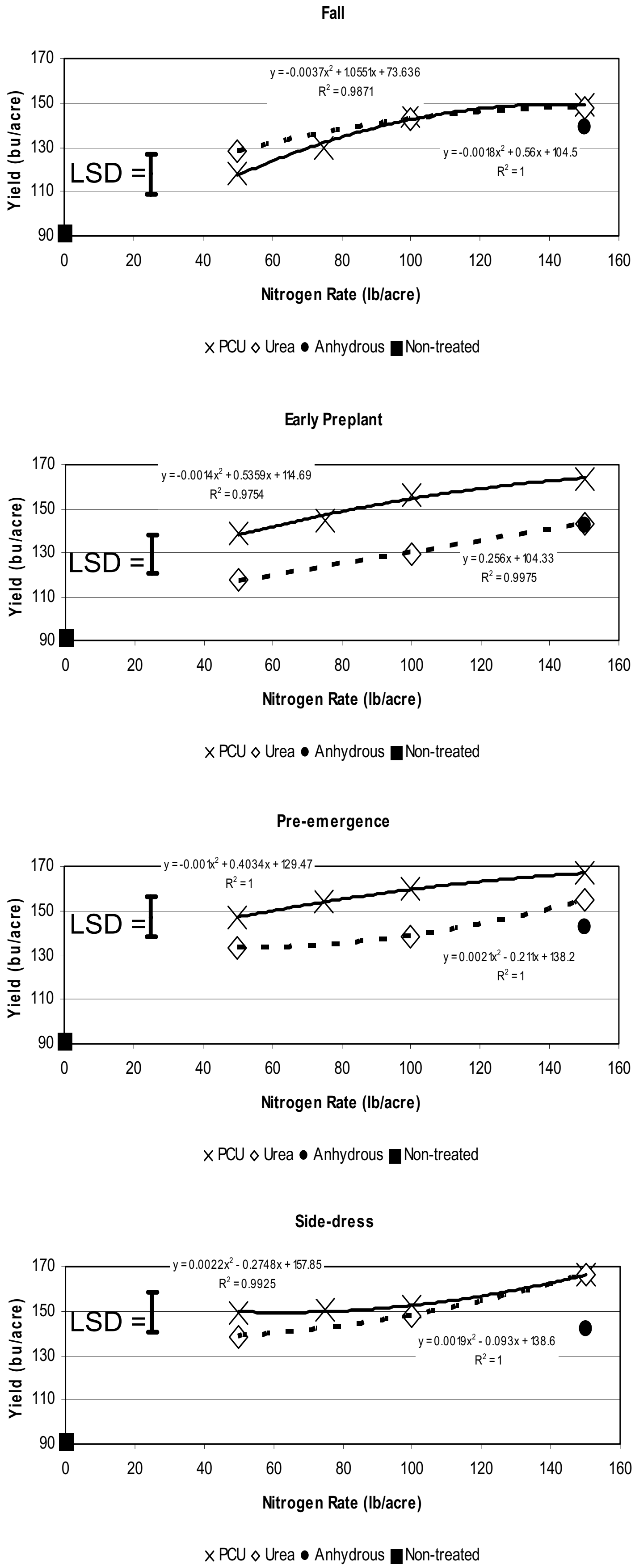

Figure 2. Yield response of no-till corn to reduced rates of polymer coated urea compared with non-coated urea at fall, early preplant, pre-emergence, and side-dress application timings in 2007.

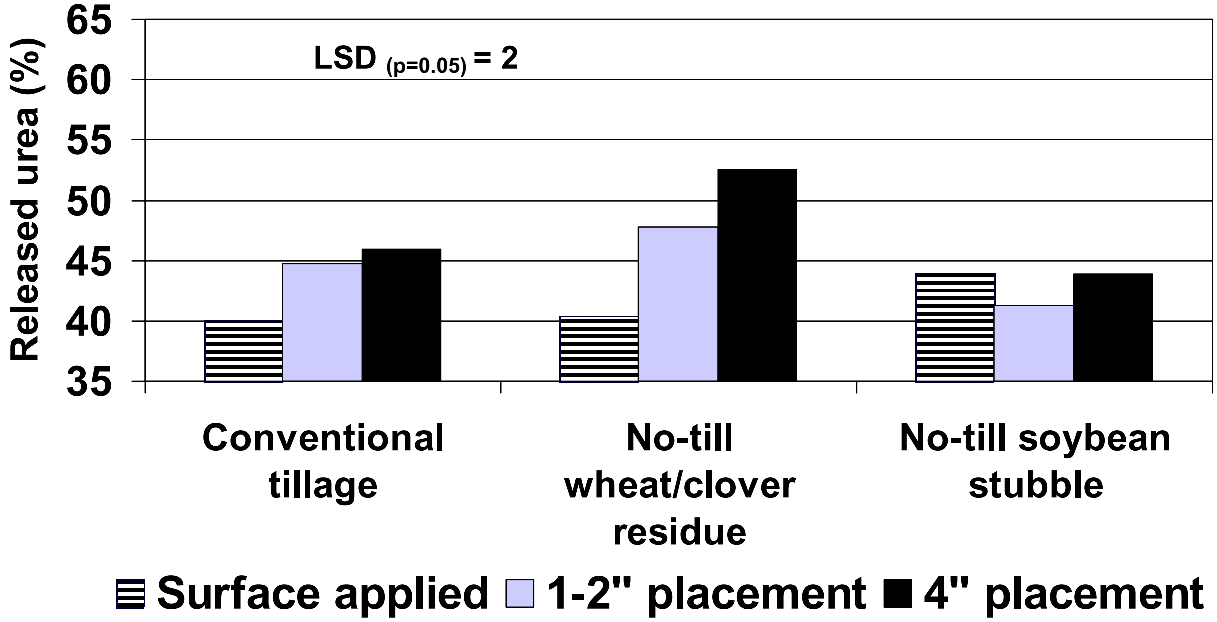

Figure 3. Effect of tillage and placement on release of fertilizer from polymer-coated urea. Data were averaged over application and removal timings in 2006.

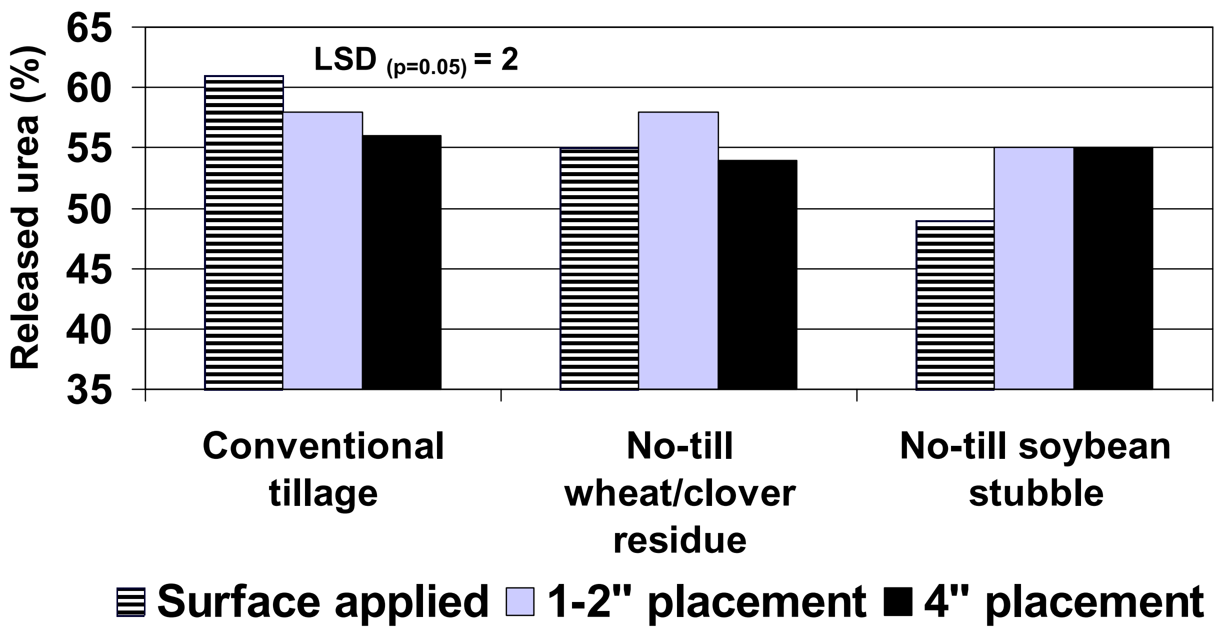

Figure 4. Effect of tillage and fertilizer placement on release of fertilizer from polymer-coated urea. Data were averaged over application and removal timings in 2007.

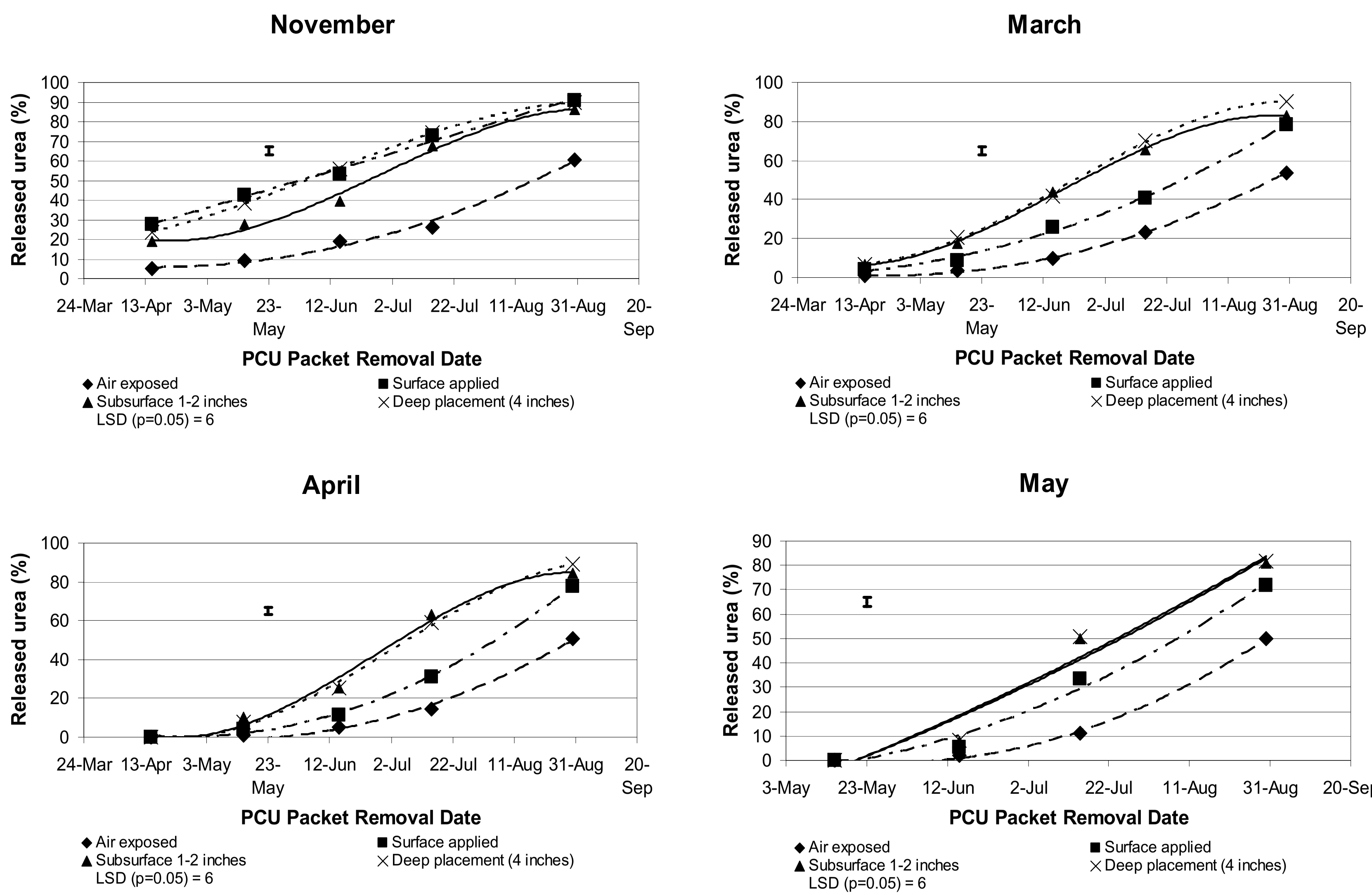

Figure 5. Polymer coated urea released from November 15, March 15, April 15, and May 15 application timings for 2006. PCU packets were removed on April 15, May 15, June 15, July 15, and August 31. Released urea values were calculated as (1-(removal date weight/weight at application))*100. Vertical bars represent LSD values (p=0.05).

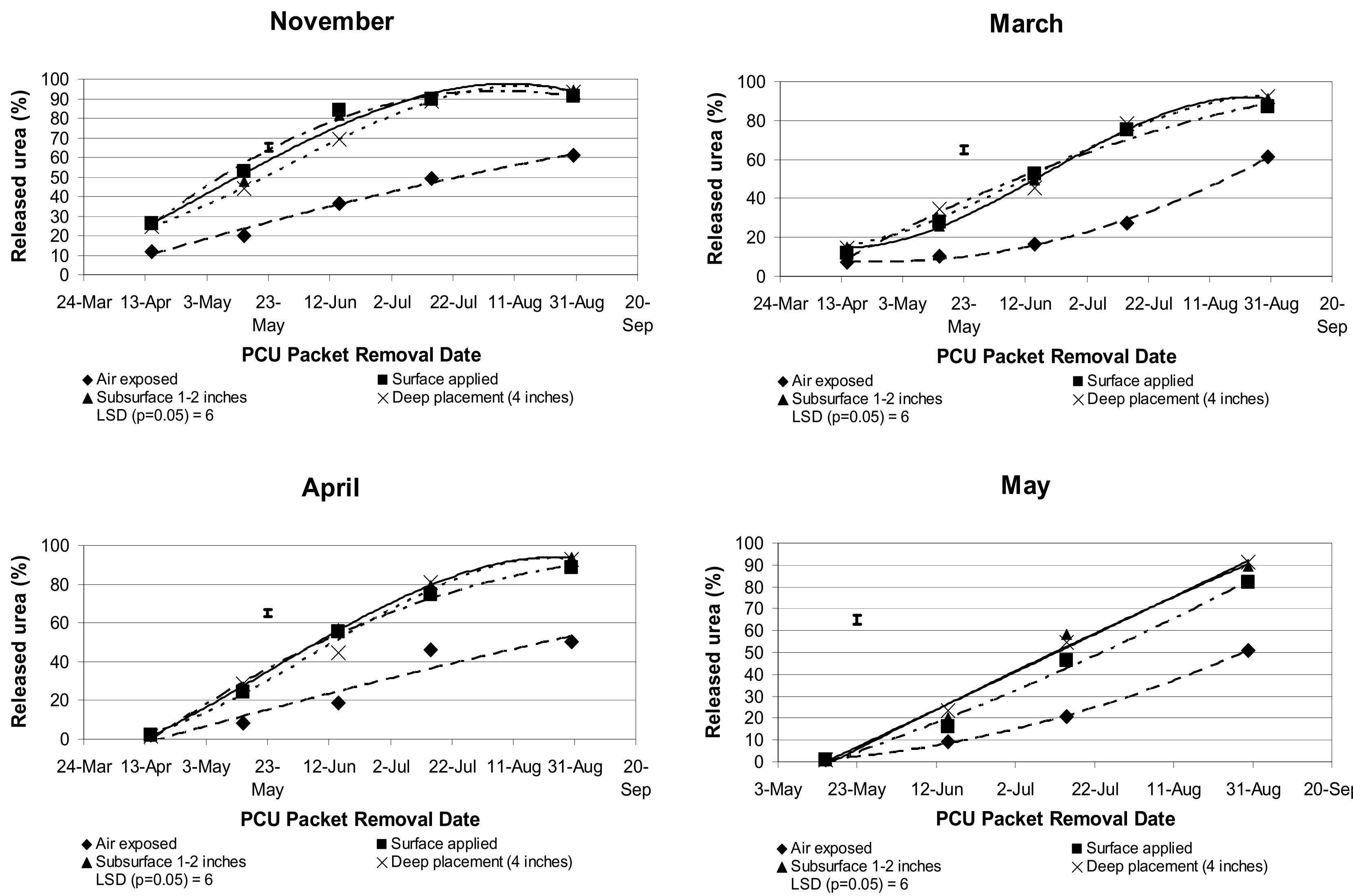

Figure 6. Polymer coated urea released from November 15, March 15, April 15, and May 15 application timings for 2007. PCU packets were removed on April 15, May 15, June 15, July 15, and August 31. Released urea values were calculated as (1-(removal date weight/weight at application))*100. Vertical bars re present LSD values (p=0.05).

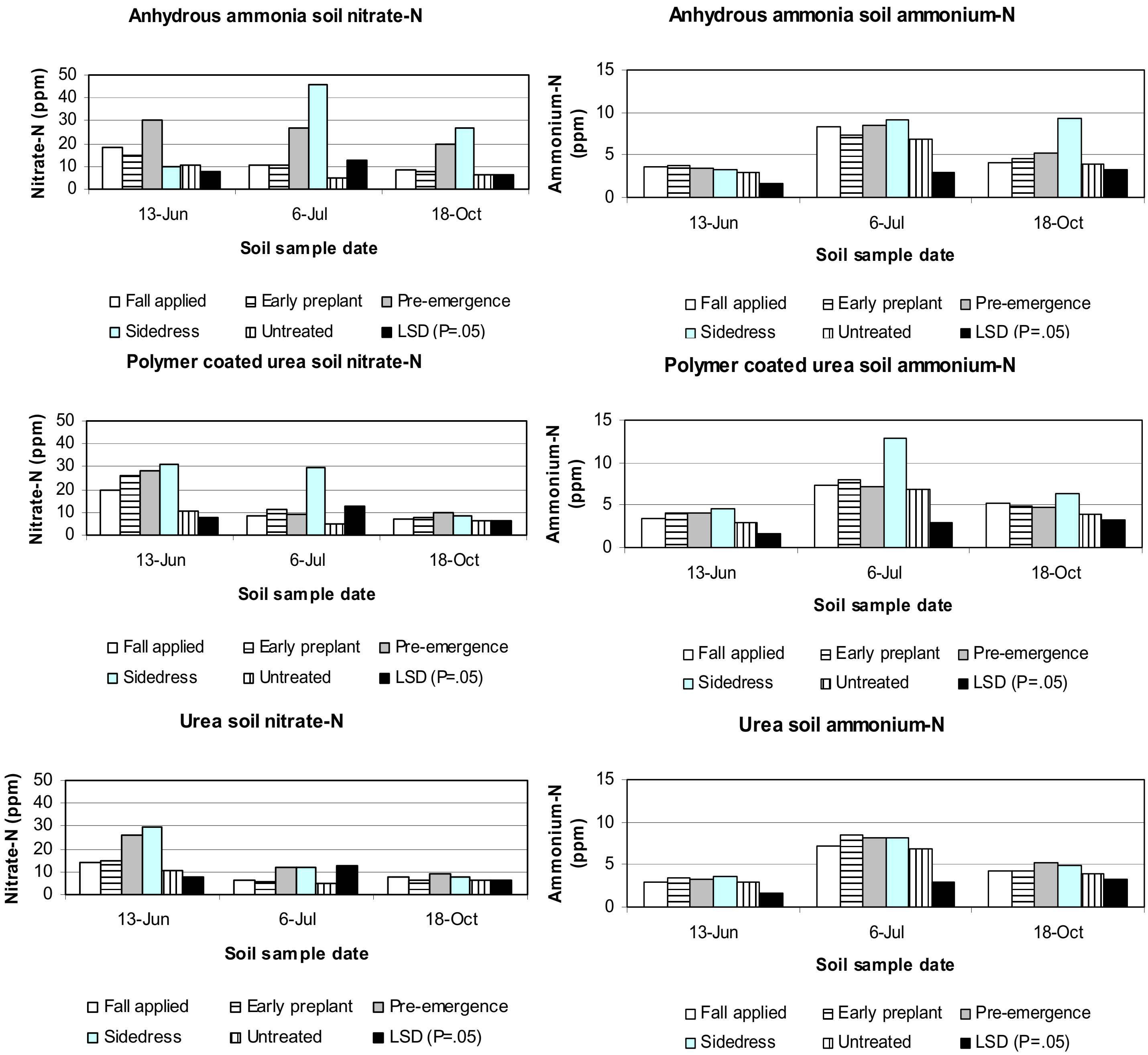

Figure 7. Anhydrous ammonia, polymer coated urea, and non-coated urea average soil nitrate- and ammonium-N concentration for soil samples 18 inches deep at Novelty in 2006. Comparisons between N sources within a soil sample date are valid.

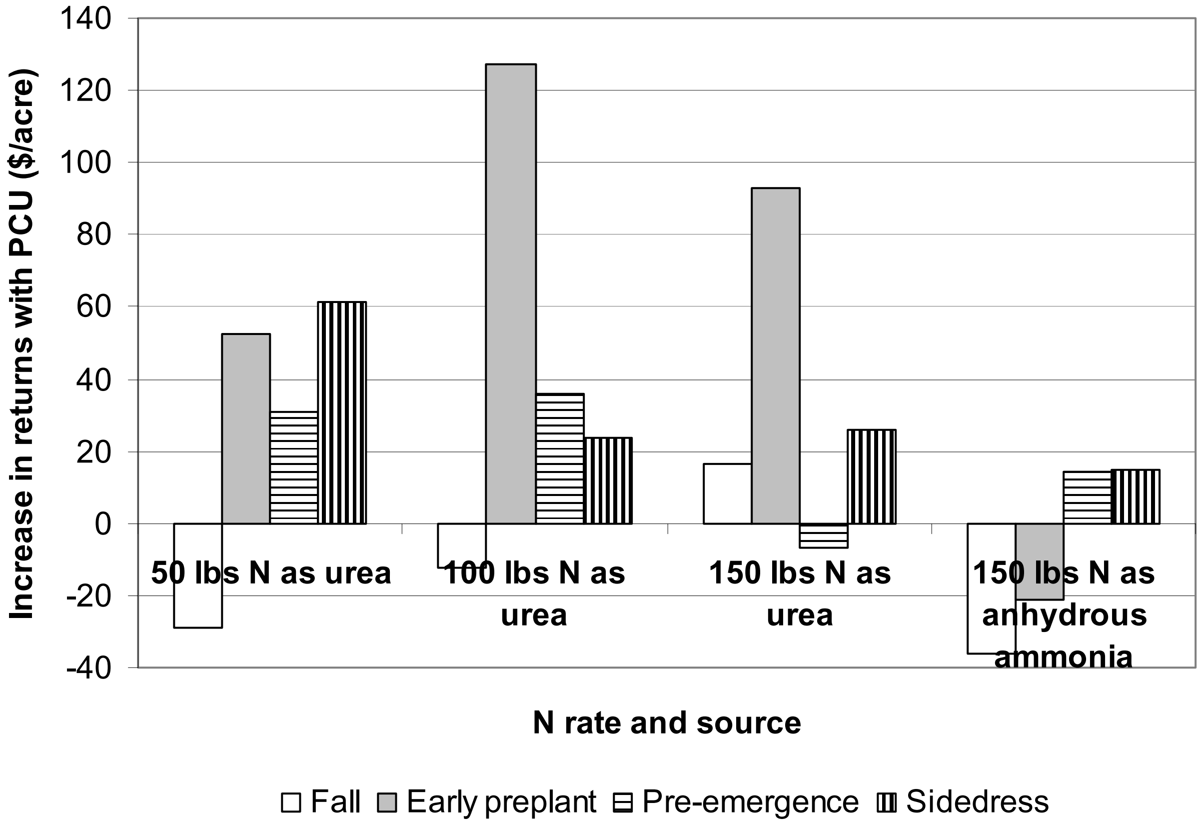

Figure 8. Increase in returns with PCU (ESN) at the same application rate as urea at 50, 100, and 150 lbs N/acre and anhydrous ammonia at 150 lbs N/acre for fall, early preplant, pre-emergence, and side-dress application timings in 2006 and 2007. Calculated as: [increase in average grain yield for 2006 and 2007 over urea or anhydrous ammonia *$3.50/bu corn] – [application + N cost]. Nitrogen cost was estimated for urea at $0.585/lb N, PCU at $0.635/lb N, and anhydrous ammonia at $0.415/lb N. Custom application cost was similar for urea and PCU at $4.80/acre while anhydrous ammonia was $0/acre.