

Utility of Polymer-Coated Urea as a Fall-Applied N Fertilizer Option for Corn and Wheat

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INTRODUCTION

Convenience, favorable soil conditions at the time of application, reduced equipment and labor demand, lower cost of nitrogen (N) fertilizer, and the ability to plant earlier in the spring following fall-applied N applications has favored fall-applied N in Missouri. Fall-applied N is particularly useful in conditions that limit nitrification especially in fine- to medium-textured soils (Bundy, 1986). However, fertilizer applications in the fall may increase risk of leaching under certain soil and weather conditions. Best management practices based on economic returns and N loss via subsurface drainage included fall N with nitrapyrin (N-serve), spring preplant and split applications of anhydrous ammonia in Minnesota (Randall et al., 2003a, 2003b). However, claypan soils in Missouri have relatively lower N leaching losses due to poor drainage through the subsoil clay layer. Farmers and custom applicators utilize weather stations that report soil temperatures at the 6 in. depth to time fall-applied anhydrous ammonia. Recently, supply of anhydrous ammonia for fall application has been limited to prepaid customers and regulations on anhydrous ammonia and ammonium nitrate may further affect availability of these N fertilizer sources. Alternatives for fall-applied N fertilizer need to be evaluated for their effects on corn and wheat performance to determine if they are cost-effective.

In two years of corn research, polymer coated urea (PCU) that was fall surface-applied for no-till corn had grain yields similar to anhydrous ammonia, but surface-applied PCU in the fall or as early preplant had lower returns than anhydrous ammonia (Nelson and Motavalli, 2007b). However, deep placement of fall-applied PCU increased yield 16 bu/acre more than deep banded urea, 28 bu/acre greater than broadcast applied PCU, and 8 bu/acre greater than anhydrous ammonia (Randall, personal communication). Nitrogen release in Missouri over the winter was less than 30% for fall applied PCU applications and there was more consistent N release when PCU was deep banded than when surface applied (Nelson and Motavalli, 2007b). Reduced efficiency of surface applied PCU may be due to denitrification losses over the winter months during freeze-thaw events. Deep banding PCU should improve efficiency and make it a cost-effective alternative to applying anhydrous ammonia. In Minnesota, soil temperatures freeze and remain frozen; however, no field research has evaluated corn response to deep banded PCU in Missouri in soils that go through several freeze-thaw cycles as an alternative to anhydrous ammonia. No research has evaluated fall strip tillage and N fertilizer management systems in Missouri. Finally, no research has compared deep banded PCU with anhydrous ammonia plus N-serve.

Wheat research in MO has evaluated application timings (Medeiros et al., 2005) and fall compared to split applications of PCU (Nelson and Motavalli, 2007a). Applications of PCU later than February resulted in grain yields less than other N sources (Medeiros et al., 2005). In four years of research, fall-applied PCU had the greatest N uptake and grain yields when compared to fall-applied urea alone (Nelson and Motavalli, 2007a). No research has evaluated fall application timings of PCU compared with other N sources to determine if a single fall application at the time of planting wheat or later had yields similar or greater than standard applications of ammonium nitrate. A single fall application would save farmers application cost of a split application in the fall and spring. Spring applications of N on wheat are usually

challenging due to wet conditions and risk of N loss. In addition, research is needed to evaluate the response of wheat to blends of urea and PCU.

The objectives of this research are to: 1) evaluate yield response of fall-applied PCU compared with non-coated urea and anhydrous ammonia with and without N-serve for corn and 2) evaluate the effect of fall-applied timings of PCU and blends of PCU with non-coated urea (NCU) on wheat yields when compared to non-coated urea and ammonium nitrate.

MATERIALS AND METHODS

Corn. Two field trials with three replications at each trial were established at the Greenley Research Center in plots 10 by 70 ft. One trial followed soybean residue and the other followed red clover residue that was frost-seeded into wheat the previous year. Treatments included PCU and non-coated urea (NCU) at 125 lbs N/acre broadcast surface applied and deep banded using a Yetter[®] 2984 strip-till system equipped with high residue Maverick[®] units with a rolling basket and dry fertilizer application tubes. A Gandy Orbit Air ground drive fertilizer applicator was used to deliver PCU and NCU for the strip-tilled treatments. Dry fertilizer was placed approximately 8 inches deep in the strip tilled region. Nitrogen treatments were applied in the fall, early preplant (approximately 1 month before planting), and prior to planting. A non-treated and standard anhydrous treatment at 125 lbs N/acre was included as controls. The N application rate was reduced to determine the most efficient N sources. Fall, early preplant, and preplant treatments were applied in both studies on 20 November 2007, 7 April 2008, and 5 May 2008, respectively.

The soybean residue study was planted to 'DKC63-42' at 30,000 seeds/acre on 6 May 2008. In the clover residue study, 'DKC61-69' was planted at 30,000 seeds/acre on 29 May 2008. The planting date in the clover residue study was delayed 24 days after the preplant fertilizer application due to wet conditions in the heavy clover residue. The planter was equipped with Shark-tooth[®] residue cleaners used in tandem with a no-till coulter. The residue cleaners performed well in heavy residue of the no-till plots and provided a smooth seedbed above in strip-tilled plots. Grain yields were determined and grain collected to evaluate for starch, protein, and oil concentration. Grain moisture was adjusted to 15% prior to analysis. A gross margin will be calculated for each treatment to compare relative returns of fall compared with preplant treatments at the conclusion of the experiment.

Wheat. Research was conducted at the Greenley Research Center near Novelty, MO from fall, 2007 to summer, 2008. This research was arranged as a randomized complete block design with five replications in 10 by 30 ft plots. 'Pioneer 25R56' was no-till drilled following an application of 10-60-140 (N-P-K) on 5 October 2007 at 120 lbs/acre in 7.5 in. rows. Research was a factorial arrangement of N source and rate (PCU at 75 and 100 lbs N/a, urea at 75 and 100 lbs N/a, and ammonium nitrate at 75 and 100 lbs N/a, PCU 75%:urea 25% at 75 and 100 lbs N/a, and PCU 50%:urea 50% at 75 and 100 lbs N/a), and application timing (October, November, December, January, February, March, April). Polymer coated urea (PCU, ESN, Agrium), non-coated urea (NCU, fast release), 75:25 PCU:NCU, and 50:50 PCU:NCU fertilizer treatments were applied at 75 and 100 lbs N/acre on 5 October 2007, 17 November 2007, 14 December 2007, 16 January 2008, 13 February 2008, 12 March 2008, and 14 April 2008. Fertilizer release was monitored using mesh bags placed on the soil surface and soybean stubble placed over the top of the bags to simulate a fertilizer application. Mesh bags were removed at each application

date and stored in a freezer. Fertilizer samples were washed in water, dried, weighed, and release was calculated based on the remaining fertilizer. Field plots were harvested with a small-plot combine. Grain moisture was adjusted to 13% prior to analysis. All data were subjected to analysis of variance and means separated using Fisher's Protected LSD ($P=0.05$).

RESULTS

The first of a three-year field trial was conducted with extremely wet soil conditions throughout the growing season in 2008. This provided a worst-case scenario for N fertilizer loss and an opportunity to evaluate fertilizer sources and strip tillage under extremely challenging weather conditions.

Corn following soybean residue. The strip-tilled bands could have been planted 3 to 4 days before the no-till plots (personal observation). Winter annual weeds are common in long-term no-till fields. Henbit was the primary winter annual weed present in this field (20-40/ft²). Henbit plants were harvested prior to a burndown herbicide application due to visual differences in weed growth between treatments. Henbit dry weights were 60 to 70% greater when PCU or NCU was broadcast applied compared to anhydrous ammonia or a strip-till band application of PCU or NCU (data not presented). Corn grain yield was ranked anhydrous ammonia = anhydrous ammonia plus N-serve = NCU strip-till \geq PCU strip-till > PCU broadcast = NCU broadcast ($P=0.0001$).

Corn following clover residue. Extremely wet conditions delayed planting 24 days after the preplant application timing. Soil moisture was high throughout the spring, 2008. The strip-till bands dried out before the no-till plots. Corn grain yield when averaged over application timing was ranked anhydrous ammonia = anhydrous ammonia plus N-serve = NCU strip-till = PCU strip-till > PCU broadcast > NCU broadcast ($P=0.0001$). There was no difference between PCU and NCU grain yields when strip tillage was utilized; however, corn grain yield was greater with PCU when fall and preplant applied when compared to NCU. Clover dry weights were approximately 20 to 25% greater when PCU or NCU was broadcast applied compared to anhydrous ammonia or strip-till band applied PCU or NCU (data not presented). No-till, broadcast urea had the greatest clover dry weights prior to a burndown herbicide application, and the lowest corn population (22,800 plants/acre) when compared to strip-tillage (24,200 plants/acre) at harvest. Strip-till application of PCU and NCU had grain yields similar to anhydrous ammonia at all of the application timings.

Wheat. Rainfall and distribution of rainfall events were extensive in the fall, 2007 and spring, 2008. Less than 20% of the PCU applied in October, 2007 was released by February, 2008 (Figure 3). Fertilizer released from the PCU applied from October, 2007 to February, 2008 was nearly 50% or greater by 15 June 2008. Less than 35% of the fertilizer was released when applied from 12 March to 15 June 2008. This indicates that residual fertilizer may be present for PCU applications in wheat. Application of PCU after 12 March required the presence of a fast release fertilizer source when applied at 100 lbs N/acre.

The non-treated check grain yield was 53 bu/acre. There was a significant grain yield response to all N treatments (Figures 4A and B). Grain yields at 100 lbs N/acre averaged 5 bu/a greater than 75 lbs N/acre (data not presented). Wheat yield was ranked PCU = 75:25

PCU:NCU \geq 50:50 PCU:NCU \geq NCU = ammonium nitrate for the October, November, December, January, February and March application timings (Figure 4B). However, the April 14 application timing resulted in grain yield rankings of ammonium nitrate = 50:50 PCU:NCU = NCU \geq 75:25 PCU:NCU > PCU (Figure 4B). Icy conditions at the December application timing and frozen conditions at the February application timing were the primary environmental conditions that may have contributed to lower yields for these application timings. In general, there was a rate response to decreasing amounts of PCU as a ratio of the N fertilizer source for the October, January, and February application timings. PCU increased average grain yields 6 bu/acre when compared to NCU for the October to February application timings; however, PCU applications in mid-March and April were 4 bu/acre less than NCU. PCU applications in Northeast Missouri from mid-March and later should increase the amount of NCU in the blend to maintain maximum grain yields based on our results in 2008. Grain yields prior to mid-March were more variable in the NCU and ammonium nitrate treated wheat when compared to PCU or blends of NCU with PCU. Fall applications of PCU or a blend of PCU:NCU at 75:25 had yields similar to or greater than spring applied N in 2008.

SUMMARY

Corn

- In an extremely wet year, fall applied urea should be deep banded to improve crop performance.
- PCU and NCU were more effective when deep banded when compared to a surface broadcast application in 2008.
- Broadcast PCU increased yield compared to broadcast NCU following clover residue in 2008.

Wheat

- Fall applied PCU is an option for wheat production in upstate Missouri.
- A ratio of fast release N fertilizer with PCU is recommended for applications after February. A 50:50 ratio of PCU:NCU or 100% NCU would be more cost-effective for March and April N fertilizer applications.

Timetable:

October-December 2007	Prepare treatments, plot preparation, and apply fall application timings for corn and wheat studies
April-September 2008	Apply preplant N treatments soil sample in the spring and prior to harvest.
September 2008	Harvest
Oct-Dec 2008	Analyze and summarize results
2009	Repeat 2008 procedures
2010	Repeat 2008 procedures

References:

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Proposed Budget:

CATEGORIES	2009 Year 2	2010 Year 3	TOTAL*
A. Salaries			
M.S. Graduate Research Assistant (50%)	\$14,382	\$14,670	\$42,875
B. Fringe Benefits			
Fringe for graduate student	\$1,995	\$2,095	\$5,990
TOTAL SALARIES AND FRINGE BENEFITS	\$16,095	\$16,765	\$48,583
C. Travel			
Travel to field site	\$623	\$623	\$1,869
Travel to professional meeting	\$500	\$500	\$1,000
TOTAL TRAVEL COSTS	\$1,123	\$1,123	\$2,869
D. Equipment	\$0	\$0	\$0
TOTAL EQUIPMENT COSTS	\$0	\$0	\$0
E. Other Direct Costs			
Laboratory reagents and supplies	\$1,000	\$1,000	\$3,000
Field supplies	\$1,500	\$1,500	\$4,500
Soil processing and analysis	\$2,000	\$2,000	\$6,000
Publications/Documentation	\$500	\$500	\$1,000
TOTAL OTHER DIRECT COSTS	\$5,000	\$5,000	\$14,500
TOTAL REQUEST	\$22,218	\$22,888	\$65,952

*Includes 2008 Year 1 budget

Justification:

Salaries and Fringe Benefits: Funds are requested for support of a graduate research assistant (50% time) based on set rates at the University of Missouri. Fringe benefits for the graduate student cover the cost of health insurance. If the graduate student does not require a third year then the requested funds will be used to partially fund a technician during that year.

Travel: Covers cost of travel to Greenley Farm at a rate of 44.5 ¢/mile. In the second and third years, \$500 is requested to cover cost of travel and board for one researcher to attend a professional conference for presentation of results.

Laboratory Reagents and Supplies: Covers cost of laboratory reagents, sample containers, and other materials used in soil and plant tissue analyses.

Field Supplies: Cost of fertilizer, seed, plot preparation, planting, weed control and harvesting, soil samplers, flags, pots and other field supplies and operations.

Soil Processing and Analysis: Covers cost of drying, grinding and analysis of soil samples for ammonium and nitrate-N.

Publications/Documentation: Defrays cost of publication and documentation of results and conclusions.

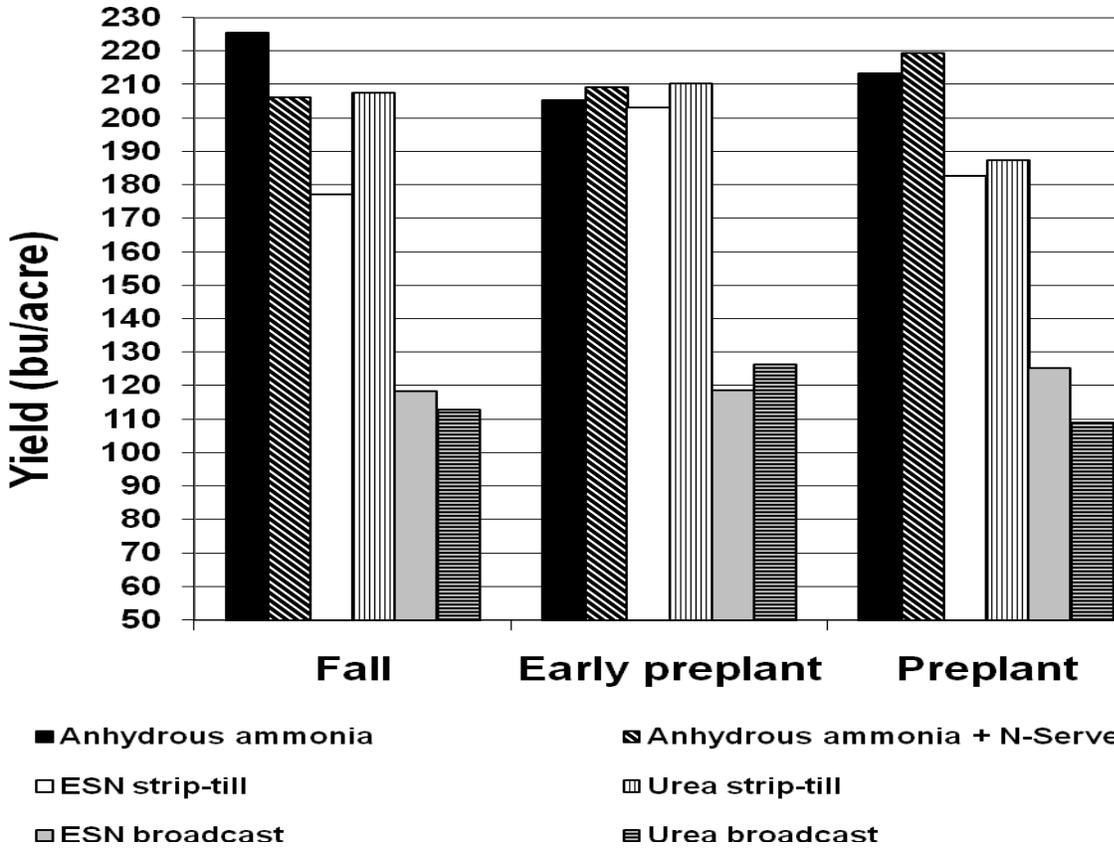


Figure 1. Corn grain yield response to N fertilizer sources applied in the fall, early preplant, and preplant following soybean residue in 2008. LSD ($P \leq 0.05$) was 25 bu/acre.

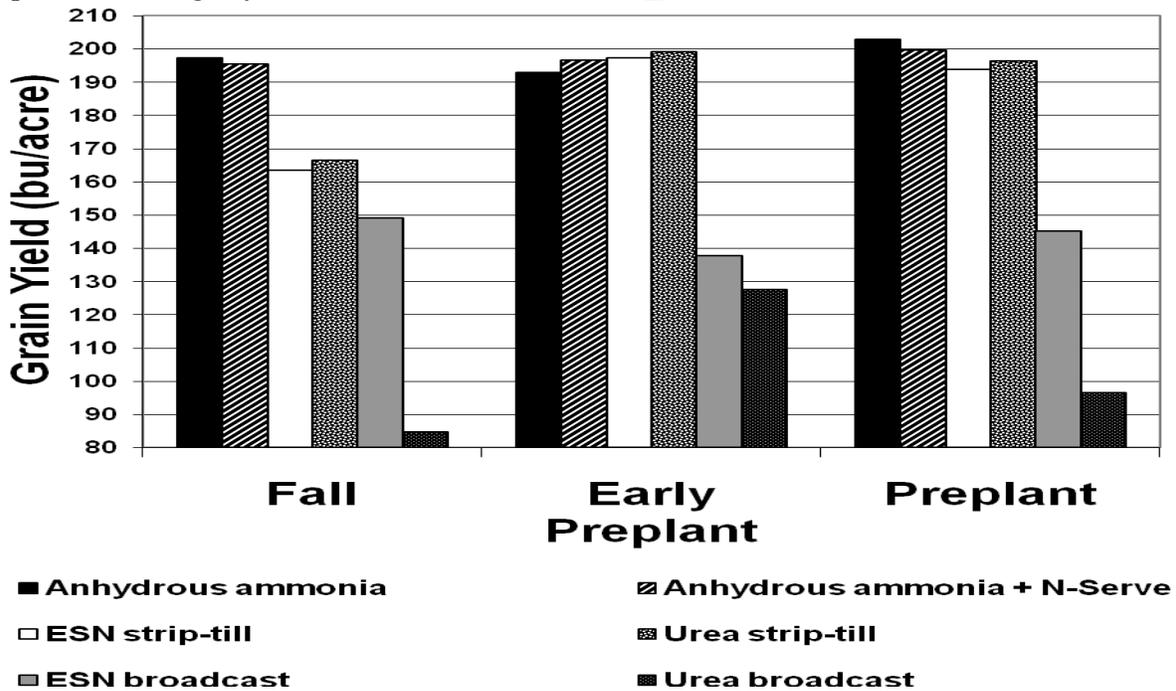


Figure 2. Corn grain yield response to N fertilizer sources applied in the fall, early preplant, and preplant following clover residue in 2008. LSD ($P \leq 0.05$) was 40 bu/acre.

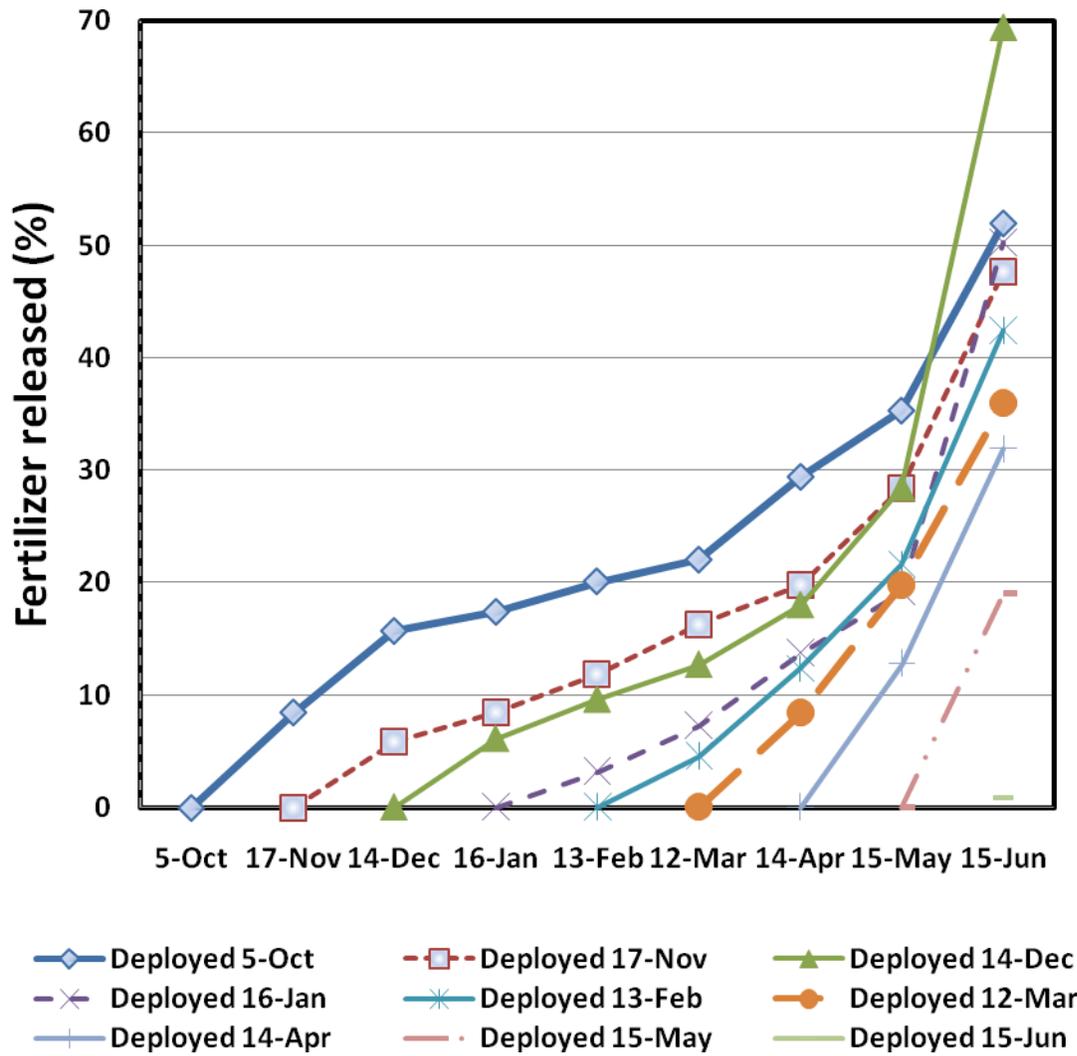


Figure 3. Polymer-coated urea (PCU, ESN) fertilizer release for individual application dates. The LSD ($P \leq 0.05$) was 5.

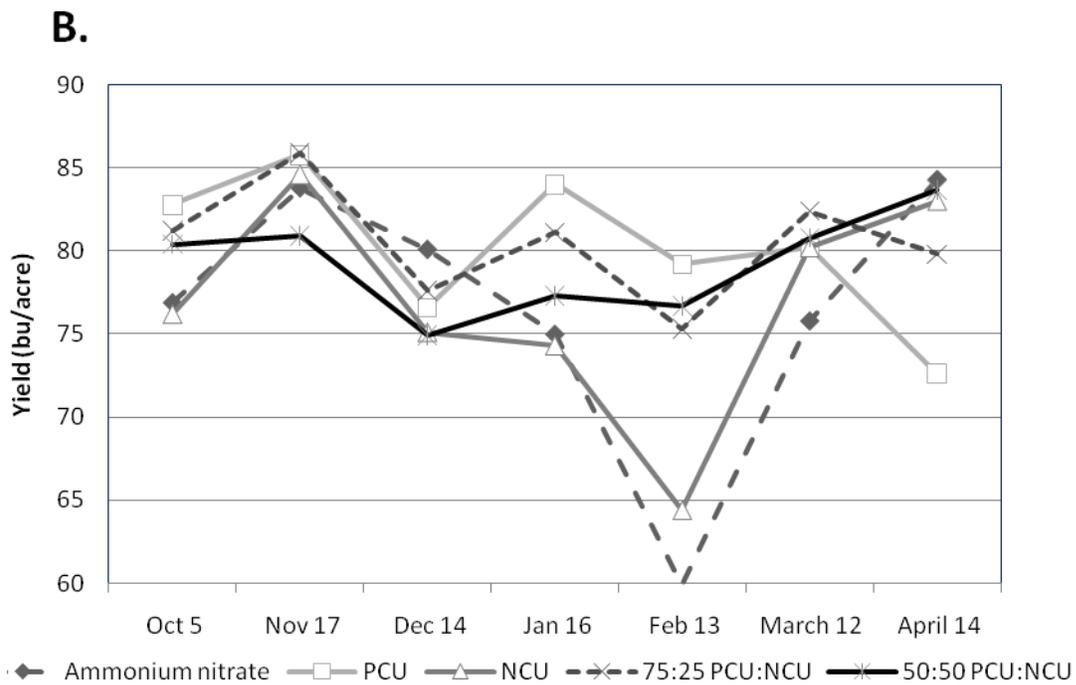
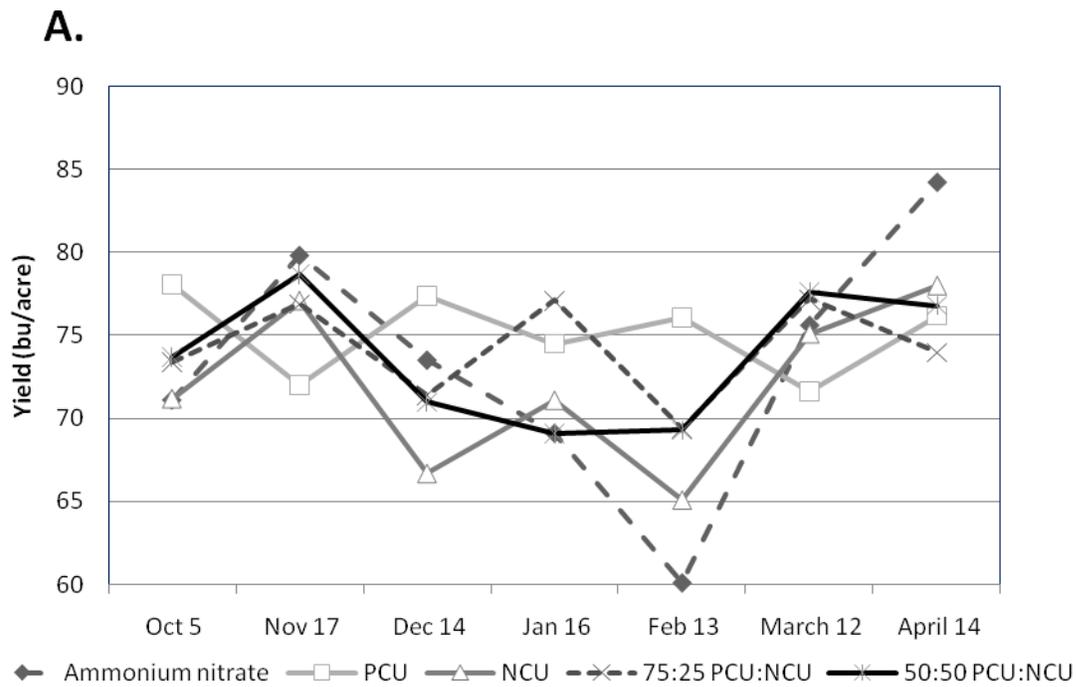


Figure 4. The effect of polymer-coated urea (PCU, ESN), non-coated urea (NCU), ammonium nitrate, 75:25 PCU:NCU, and 50:50 PCU:NCU application timings and ratios at 75 (A) and 100 (B) lbs N/acre on wheat grain yield in 2008. The non-treated control grain yield was 53 bu/acre. LSD ($P \leq 0.05$) was 4 bu/acre.