COATED UREA SOURCES IMPROVE NITROGEN RECOVERY AND GRAIN YIELD OF CORN

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ABSTRACT

While urea (46-0-0) is a commonly used nitrogen (N) fertilizer source used in global corn (*Zea mays* L.) production, it is prone to losses due to volatilization if left unincorporated or to leaching after dissolution into ammonium and nitrification to nitrate, lowering its season-long plant availability and leading to poor fertilizer recovery use efficiency. Therefore, the objective of this study was to evaluate the potential of different polymer-coated urea products to improve plant N accumulation, fertilizer recovery efficiency, and grain yield of corn when compared to conventional uncoated urea. Fertilizer treatments were initiated in 2025 at Champaign, IL, and consisted of seven treatments: 1) an unfertilized control (UTC) to evaluate the N supplied by the soil; 2) uncoated urea at 150 lb N/acre; 3) Environmentally Smart Nitrogen (ESN) at 150 lb N/acre; 4) PurYield 2 at 150 lb N/acre; 5) uncoated urea at 180 lb N/acre; 6) ESN at 180 lb N/acre; and, 7) PurYield 2 at 180 lb N/acre. All N treatments also received 30 lbs N/acre as uncoated urea to supply an initial amount of available N, with all N sources broadcast applied in the spring before planting and lightly incorporated with a harrow. All treatments that supplied N increased grain yield over the unfertilized check by 109-123 bu/acre, and all treatments containing coated urea resulted in additional plant N accumulation, better apparent recovery efficiency of applied fertilizer N, and higher grain yields than those with uncoated urea. These data show that polymer-coated urea can improve corn productivity due to an improvement in the apparent recovery efficiency of fertilizer N.

INTRODUCTION

As input costs continue to increase and profit margins for producers are becoming tighter, many are taking a closer look at management of their fertilizer inputs to maximize return on investment. Selecting the appropriate fertilizer source is one of the most important for maximizing crop yield in a cost-effective way. Nitrogen (N) is one of the most applied synthetic nutrients in global agriculture **(**Food and Agriculture Organization of the United Nations, 2025), and in the United States, N is applied to approximately 95% of corn acres, with an estimated 12.3 billion lbs applied annually (average rate of 150 lbs/acre) (NASS, 2021). Various fertilizer N sources are used to supplement soil N supply to maximize corn grain yield and economic return, with urea the being most utilized source globally. In 2024, approximately 60.1 million metric tons of urea were used in agricultural production, 38.2 million metric tons more than the next most used fertilizer input (Statista

Research Department, 2024). Despite its widespread use, urea as a N fertilizer is difficult to manage because of its susceptibility to volatilization loss after application if left unincorporated on the soil surface. Alternatively, if incorporated, following dissolution and hydrolysis urea is rapidly converted to ammonium (NH_4^+) which can subsequently undergo nitrification to form nitrate (NO_3^-) and potentially lost due to leaching. Collectively, these two loss pathways can reduce the amount of N available for the crop uptake throughout the season.

The availability of fertilizer N in the soil and utilization by crops is dependent on numerous weather, biological, soil, and genetic interactions with the applied source, and these factors influence a crop's capacity to acquire and use fertilizer N for yield enhancement. The value of fertilizer N to produce additional grain yield over the soil supply can be quantified as N use efficiency, (NUE, the additional grain yield produced per unit of fertilizer N). Furthermore, the calculation of N recovery efficiency, (NRE, the percentage of fertilizer N acquired by the crop) can determine how much of the supplied fertilizer-N was utilized by the crop (Moll et. Al., 1982). Improving the recovery and subsequent efficiency of fertilizer-N by crops is crucial for reducing the cost of inputs, increasing yields, and minimizing adverse environmental impacts from N fertilization (Cassman et al., 2003). Reducing these environmental losses while improving grain yield and NRE can be achieved with better synchrony between the availability of fertilizer N and the plant N demand throughout the growing season (Cassman et al., 2002). Corn's rapid uptake of N does not occur until the mid-vegetative stages (~7 lbs of N/acre/day) from V8 – R1, while a third of the total N uptake typically occurs during reproductive growth and is a large source of grain N (Bender et al., 2013). Prolonging the availability of N throughout the growing season when the plants actively need it is a potential way to increase NRE, NUE, and final grain yields.

One way to achieve this with urea is to add a polymer coating to the fertilizer prill that minimizes early-season dissolution. The coating serves as a semi-permeable membrane that protects the urea prill from microbes, volatilization, or leaching, (i.e. a protective barrier separating the urea from the environment). Over time the membrane slowly degrades, releasing N throughout the season more slowly instead of a short period of time after application if left uncoated. This is then hypothesized to prolong N availability, improving the synchrony between availability and plant demand, therefore improving NRE while minimizing environmental loss.

MATERIALS AND METHODS

Site Description

A field experiment was conducted in 2025 at the Crop Sciences Research and Education Center at Champaign, IL. The soil in the field was a Drummer silty clay loam, (fine, smectitic, mesic Aquic Argiudoll). The site was soil sampled pre-plant at a depth of 0-6 inches and analyzed for mineral nutrients with an additional sample at the 0-12 inch depth analyzed for total N. The site had a soil organic matter (SOM) concentration of 4.2%, pH of 6.3, a CEC of 19.9 meq/100g, Mehlich III extractable P and K levels (0-6 inch depth) of 32 and 167 ppm, respectively, and pre-plant nitrate and ammonium levels (0-12 inch depth) of 7.2 and 4.5 ppm, respectively. The site followed a traditional corn-soybean [*Glycine max* (L.) Merr.] rotation with soybean as the previous crop.

Experimental Design and Agronomic Management

Treatments were replicated six times in a randomized complete block design. Each experimental unit (plot) compromised of four rows, each measuring 37.5 feet in length and spaced 30 inches apart, with a 30-inch walkway separating adjacent ranges of plots. Rows one and four of each plot served as border rows while rows two and three were considered yield rows. Corn hybrid G13U96 (Syngenta, Greensboro, NC) was planted at a population of 34,000 plants/acre on April 24, 2025, using a custom 4-row Precision Planter from Precision Planting (Precision Planting, Tremont, IL).

Treatment Applications

Three fertilizer-N sources of uncoated urea (46-0-0), polymer coated urea as ESN (Environmentally Smart Nitrogen, Nutrien, Saskatoon, SK) (44-0-0), and polymer coated urea as Puryield2 (Pursell Fertilizer, Sylacaug, AL) (44.5-0-0) were all applied at 150 or 180 lbs N/acre for a total of six fertilizer treatments. A seventh treatment included a check plot that received no N fertilizer to assess the supply of N from the soil and calculation of NRE. All fertilized plots (uncoated or coated) treatment received an upfront application of 30 lbs N/acre as uncoated urea to ensure all plots had an initial amount of available N, bringing the total application amounts to 180 or 210 lbs N/acre. All treatments were broadcast-applied before planting using a handheld spinner spreader and lightly incorporated with a harrow.

Measured Parameters

Corn N accumulation was measured by collecting the entire above-ground portion of four plants from the center two plot rows (two plants from each row) of each plot at the R6 growth stage. Plants were partitioned into stover (including leaves, stalks, husks, and cobs) and grain tissues. Stover whole plant tissues were weighed fresh before shredding with a commercial brush chipper (BC600XL, Vermeer Corporation, Pella, IA) to obtain a

representative subsample. Stover subsamples were then weighed fresh followed by drying to constant weight in a forced air oven at 167˚F and re-weighed to determine fresh weight moisture concentration and calculate total dry shoot biomass per plant. Once weighed, subsamples were ground to pass through a 2mm screen using a Wiley Mill (Thomas Scientific, Swedesboro, NJ) and analyzed for N concentration using a combustion-based analyzer (EA1112, CE Elantech, Lakewood, NJ). Nitrogen content in the stover was calculated as the product of stover dry matter and stover N concentration.

Following crop dry down, the center two rows of each plot were mechanically harvested for determination of crop grain weight and moisture using an R1 rotary combine (ALMACO, Nevada, IA). Grain yield data was then standardized to 15.5% moisture and presented on a per-acre basis. Grain N concentration at R6 was determined using combine-harvested grain subsample by dividing the grain protein concentration, obtained using near-infrared transmittance spectroscopy (Infratec 1241 Grain Analyzer; FOSS North America, Eden Prairie, MN), by a factor of 6.25 (Jones, 1941). Nitrogen content in the grain was calculated as the product of grain dry matter and grain N concentration.

Total N uptake at R6 was calculated as the sum of total N in the grain and total N in the stover. The NRE, (lbs fertilizer N uptake / lbs fertilizer N applied) was calculated using the following equations:

$$NRE = \frac{R6N_{fert} - R6N_{0N}}{N\ rate}$$

Where $R6N_{fert}$ and $R6N_{0N}$ refer to total R6 N content in the fertilized and unfertilized plants respectively. All fertilized treatments in this study received a total N rate of 180 or 210 lbs N/acre, which was used as the denominator N rate in calculating NRE of respective treatments.

Statistical analysis was performed using a linear mixed model approach in PROC MIXED of SAS (SAS 9.4) (SAS Institute Inc., Cary, NC), and means were separated using Fisher's protected LSD test. Assessment of normality of residuals and detection of potential outliers was conducted with PROC UNIVARIATE. Additionally, the Brown-Forsythe modification of the Levene test was performed using PROC GLM to ensure homogeneity of variance. The assumptions of homogeneity of variance and normality were confirmed, and no data transformations were needed.

RESULTS AND DISCUSSION

Weather

The 2025 crop season at the Champaign site received 9.2 inches (-37%) less precipitation than the 30-year average (1989-1920), with all months from April to September receiving less than the average precipitation (Table 1). Early season dryness allowed for relatively early planting in the second half of April. August and September received the lowest precipitation, the critical time for the grain filling and vegetative remobilization of nutrients. The monthly average temperatures throughout the growing

season were only similar to the 30-year averages for May and August whereas the other months had temperatures above average, with June and July achieving 75°F and 78°F, respectively, an average increase of 3°F (+4%) over the 30-year average. Daily precipitation and average temperature during the production season at Champaign, IL, in 2025. Values were obtained from the Illinois State Water Survey (Figure 2).

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Yield, Yield Components, and Grain Quality

All the treatments that supplied N increased grain yield over the unfertilized check plot by 109-123 bushels per acre (Table 2). All treatments containing coated urea exhibited higher yields than those with traditional urea, especially at the rate of 150 lbs of N/acre. The late-season drought in August and September (Table 1 and Figure 2) limited the response to additional N when comparing the total N rates of 180 and 210 lbs N/acre. In contrast, prolonged soil saturation observed during the wet spring potentially increased urea losses, while both coated urea sources preserved N availability during the critical period for kernel set. The PurYield 2 treatment resulted in significantly greater stover biomass at the 150 lbs N rate, and significantly higher grain and total N accumulation at R6, and higher N recovery efficiency compared to the uncoated urea. At 180 lbs N/acre, ESN significantly increased grain N accumulation, while both urea coatings increased stover N concentration, leading to greater stover and total N accumulation and higher N recovery efficiency than uncoated urea (Table 2, Figure 1).

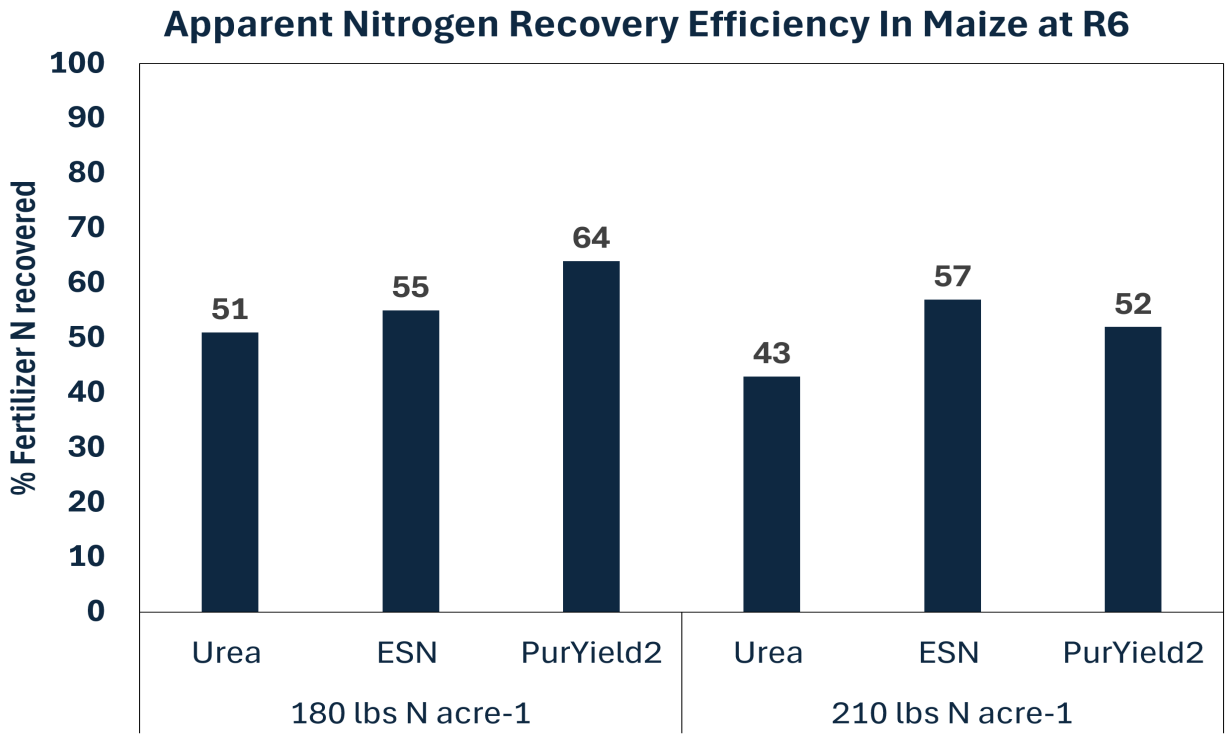


Figure 1. The effect of N rate and the source of urea (uncoated or coated) fertilizer on the apparent plant recovery efficiency of the applied fertilizer. Nitrogen recovery efficiency

was calculated by subtracting the total N uptake of the check plots from total N uptake of N treated plots and dividing by the total amount of N fertilizer applied.

CONCLUSION

While a late-season drought limited the response to additional N preplant applied at 180 and 210 lbs N/acre, the coated urea products increased grain yield over traditional uncoated urea, especially at the lower N rate. At the 180 lbs/acre rate, PurYield 2 resulted in significantly greater grain N accumulation due to increases in both plant biomass and N concentration. At the 210 lbs N/acre rate, ESN increased stover production and both ESN and PurYield 2, increased stover N concentration, leading to greater stover, grain, and total N accumulation with both polymer coated urea sources. These results suggest that polymer-coated urea products improved N availability and plant N acquisition, resulting in improved N recovery efficiency and increased grain yield compared to uncoated urea.

Table 1. Monthly weather (precipitation and average temperature) during the production season at Champaign, IL, in 2025, compared to the 30-year average (1989-2020). Values were obtained from the Illinois State Water Survey.

	Precipitation (in)		Temperature (°F)	
Month	**2025**	**30-Year Average**	**2025**	**30-Year Average**
	Champaign			
April	3.4	4.0	54	53
May	2.5	5.0	63	63
June	3.2	4.7	75	72
July	3.6	4.4	78	75
August	1.2	3.5	74	74
September	1.8	3.3	70	67
Total	15.7	24.9	-	-

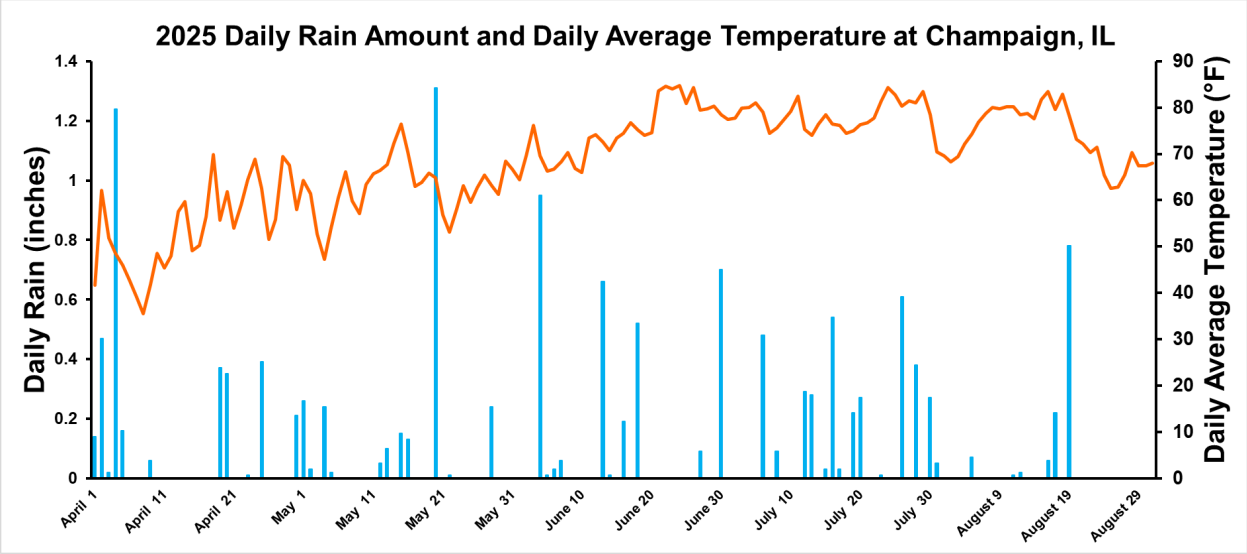


Figure 2. Daily precipitation and average temperature during the production season at Champaign, IL, in 2025. Values were obtained from the Illinois State Water Survey. The day's precipitation is denoted by a blue bar (left y-axis), while the orange line denotes the average daily temperature (right y-axis).

Table 2. Effect of uncoated urea and different time-release coated urea products applied at 150 and 180 lbs N per acre on corn grain yield, R6 biomass and nitrogen uptake at Champaign, IL, in 2025.

Treatment †	Grain Yield	Harvest Index	Total Stover Dry Biomass	R6 Stover N	R6 Stover N	R6 Grain N	R6 Total N Uptake
	bu/acre	%	tons/acre	%	lbs/acre	lbs/acre	lbs/acre
Check Plot	110	0.44	3.31	0.33	21	59	85
150 lbs N as Urea	219	0.57	3.97	0.46	37	136	172
150 lbs N as ESN	222	0.57	3.89	0.48	38	142	180
150 lbs N as PurYield 2	228	0.56	4.32	0.53	42	149	189
180 lbs N as Urea	225	0.58	3.90	0.44	35	137	171
180 lbs N as ESN	230	0.57	4.20	0.60	50	150	200
180 lbs N as PurYield 2	233	0.59	3.82	0.59	45	148	193
LSD Treatment (α=0.1)	9 (p < 0.0001)	0.02 (p < 0.0001)	0.35 (p = 0.0017)	0.07 (p < 0.0001)	5.7 (p < 0.0001)	11.2 (p < 0.0001)	12.8 (p < 0.0001)

† All N treatments received an additional 30 lbs N/acre as uncoated urea to assure that plants had an initial supply of available

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