

Effects of Enhanced Efficiency Urea on No-tillage Corn Yields and Profit

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Summary

This publication reviews the profitability of enhanced efficiency (EE) urea products relative to conventional urea and ammonium nitrate fertilizers for no-tillage corn. EE urea is an amended urea product containing urease inhibitors that reduce nitrogen losses to the air for fertilizer applied to the soil surface under no-tillage. Corn yields and profitability for the different nitrogen fertilizer products are from field experiments conducted at Jackson, Milan and Springfield, Tennessee. The key findings are:

- Urea + nitrogen-(n-butyl)-thiophosphoric triamide (NBPT) and polymer-coated urea (PCU).
 - The two amended nitrogen fertilizers produced the highest corn yields and net returns (corn revenue minus nitrogen fertilizer cost) among the EE urea fertilizers;
 - However, the two amended nitrogen fertilizers did not produce corn yields and net returns similar to ammonium nitrate under no-tillage growing conditions in Tennessee. Ammonium nitrate produced higher yields than urea + NBPT or PCU and was the most profitable nitrogen fertilizer option. However, security concerns may limit its availability as a source of nitrogen for farmers.

- Urea + NBPT and PCU offer greater potential to improve profitability than urea + maleic-itaconic acid copolymer (MICP).
 - The addition of MICP to urea did not improve corn yields or net returns compared with conventional urea. In fact, yields were significantly lower with MICP compared with the other EE urea products.

Introduction

Ammonium nitrate (AN) has been an important source of fertilizer nitrogen (N) in no-tillage crop production; however, security concerns have limited the availability of AN as a source of fertilizer N. Urea is a readily available source of N that can substitute for AN in no-tillage systems. Unfortunately, conventional urea, which is not amended to protect from surface volatilization loss, is subject to substantial losses of N to the air if it is surface applied rather than incorporated into the soil. Several N stabilizer products that act as urease inhibitors may enhance the efficiency of urea applied to the surface of the soil in no-tillage crop production. However, the profitability of enhanced efficiency (EE) urea products has not been documented under Tennessee growing conditions. Farmers need information about the effects of EE urea on no-tillage corn yields and profits. This publication reports on the profitability of alternative EE urea products relative to conventional urea and ammonium nitrate fertilizers for no-tillage corn. Costs and benefit trade-offs of alternative EE urea products are illustrated using no-tillage corn yields and net returns (corn revenue minus nitrogen fertilizer cost) from an Agronomy Journal article by Zhou et al. (2018).

Methods

Corn yields obtained with alternative N fertilizer products including EE urea were from field experiments conducted in 2013, 2014 and 2015 at the West Tennessee (Jackson), Milan, and Highland Rim (Springfield) AgResearch and Education Centers (**Table 1**). The fertilizer treatments were:

- No N fertilizer (0% N),
- AN (34% N),
- Conventional urea (46% N),
- Urea + 20% nitrogen-(n-butyl)-thiophosphoric triamide (NBPT, trade name Agrotain),
- Urea + 26.7% NBPT (trade name Agrotain Ultra),
- Urea +30-40% Ca salt of maleic polymer (MICP, trade name Nutrisphere-N), and
- Polymer-coated urea (PCU, 44% N, trade name Environmentally Smart Nitrogen).

The no N fertilizer treatment served as a control for observing whether there was a positive yield response to N fertilizer. AN was also included as a fertilizer control. AN does not volatilize from the soil surface of no-tillage fields as readily as urea. N fertilizer rates were 110 and 150 lb/acre of N. Fertilizer rates in the experiment were lower than typically recommended to maximize profit to ensure separation in yield with products that may not have any effect in reducing N volatilization. The fertilizer treatments were set up in an experimental design so that yield and profitability results could be evaluated using commonly

Table 1. Locations and soil types for the enhanced efficiency urea field experiments

Year	Location	Soil Type
2013	Milan, TN	Loring silt loam
2013	Springfield, TN	Hamblen silt loam
2014	Jackson, TN	Memphis/Loring silt loam
2015	Jackson, TN	Memphis/Loring silt loam
2015	Springfield, TN	Hamblen silt loam

accepted statistical procedures. More information about the experiment is in the Agronomy Journal article by Zhou et al. (2018).

The measure of profit was corn revenue [corn price (\$/bu) × corn yield (bu/acre)] minus the cost of a fertilizer treatment [N fertilizer price (\$/lb N) × N fertilizer rate (lb/acre N)]. An average corn price of \$4.06 per bushel for 2000 through 2015 was used to calculate net returns above N fertilizer (nitrogen) costs (<http://quickstats.nass.usda.gov/>). The estimated cost of each N fertilizer on a dollar per pound of elemental N basis is in **Table 2**. The respective costs of \$0.48 and \$0.55 per pound for conventional urea and AN are the average of prices reported in University of Tennessee Extension budgets for 2000 through 2015 (<https://ag.tennessee.edu/arec/Pages/budgets.aspx>). The estimated additional cost of EE urea over conventional urea ranged from \$0.07 per pound of N for urea + 20% NBTP to \$0.22 per pound of N for PCU. Corn and fertilizer prices are expressed in constant 2015 dollars to eliminate the effects of price inflation. Changes in corn yields and N costs with different sources of N fertilizer are the two primary factors influencing profitability. The price premium for AN over conventional urea averaged \$0.07 per pound between 2000 and 2015, but the premium varied from \$0.00 to \$0.18 per pound of N during the period. Another useful profitability measure is the estimated difference in corn yields between AN and EE urea for a given AN price premium that provides an equal profit for the two fertilizers. The estimated yield differences for EE urea to provide an equal profit with AN are compared with the corn yield differences obtained in the field experiment.

Table 2. Nitrogen (N) fertilizer product costs

N Fertilizer Product/ Trade Name	Active Ingredients	Materials Cost (\$/lb N)
Ammonium Nitrate (34-0-0) ^a	34% N	0.55
Conventional Urea (46-0-0) ^a	46% N	0.48
Urea + Agrotain ^b	46% N, 20% N butyl thiophosphoric triamide (NBPT)	0.55
Urea + Agrotain Ultra ^c	46% N, 26.7% NBPT	0.56
Urea + NutriSphere-N ^d Environmentally Smart Nitrogen ^e	46% N, 30-40% Ca salt of Maleic polymer (MICP) 44% N, Polymer Coated Urea (PCU)	0.55 0.70

^a Average of ammonium nitrate and conventional urea prices per pound of N reported in University of Tennessee Extension Crop Budgets for 2000 through 2015 (<https://ag.tennessee.edu/arec/Pages/budgets.aspx>). Prices are expressed in constant 2015 dollars to eliminate the effects of price inflation.

^b 20% NBPT material cost is based on \$80/gallon and 3 qt/ton of urea label rate or \$60/ton of urea fertilizer or about \$0.07/lb N [$\$60/(46\% \times 2000 \text{ lb})$].

^c 26.7% NBPT material cost is based on \$93/gallon and 3 qt/ton of urea label rate or \$69.75/ton of urea fertilizer or about \$0.08/lb N [$\$69.75/(46\% \times 2000 \text{ lb})$].

^d MICP material cost is based on \$120/gallon and a 2 qt/ton of urea label rate or \$60/ton of urea fertilizer or about \$0.07/lb N [$\$60/(46\% \times 2000 \text{ lb})$].

^e Assumes a price premium of \$0.20/lb N for PCU over conventional urea (<http://www.smartnitrogen.com/roi-calculator>). The price of urea is adjusted from 46% to 44% [$\$0.48/\text{lb} \times (46\%/44\%) = \$0.50/\text{lb N}$].

Data Source: Zhou et al. (2018).

Results and Discussion

Urea + NBPT at both concentrations (20% and 26.7%) and PCU produced significantly higher yields than conventional urea (**Figure 1**). The three EE urea fertilizers gave similar yields that averaged 32 more bushels per acre than conventional urea across the two nitrogen rates in the study. Corn ears collected from the conventional urea experiment plots exhibited nitrogen deficiency relative to urea + NBPT and PCU (**Figure 2**). The additional yields with urea + NBPT (both concentrations) or PCU produced \$115 per acre higher net returns above fertilizer costs, on the average, than conventional urea (**Figure 3**). However, the addition of

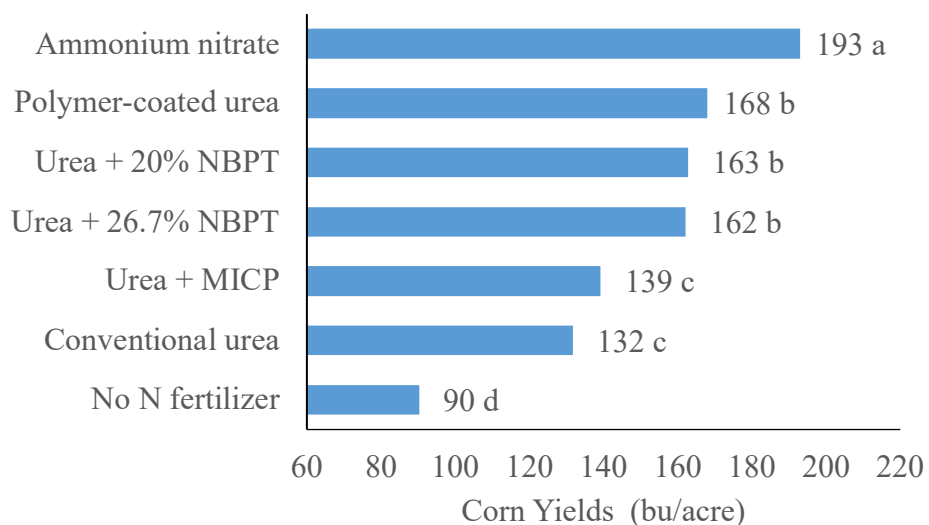


Figure 1. Corn yields for no nitrogen fertilizer, ammonium nitrate, conventional urea and enhanced efficiency urea fertilizers averaged over three experiment locations (Jackson, Milan, Springfield) and three growing seasons (2013, 2014 and 2015).

Notes: Nitrogen treatments are described in **Table 2**. Corn yields for the nitrogen fertilizer treatments are averaged across the two nitrogen fertilizer rates (110 and 150 lb/acre) used in the experiment. Letters after corn yield for each fertilizer treatment that are different from each other indicate a statistically significant yield difference from the yields of the other nitrogen fertilizer treatments. Data source: Zhou et al. (2018).

MICP to urea did not increase corn yields and net returns over conventional urea. Yields and net returns for urea + MICP were significantly lower than the yields observed with urea + NBPT or PCU. The aforementioned results indicate that urea + NBPT and PCU are potentially effective in providing higher no-tillage corn yields and net returns than conventional urea under Tennessee growing conditions.

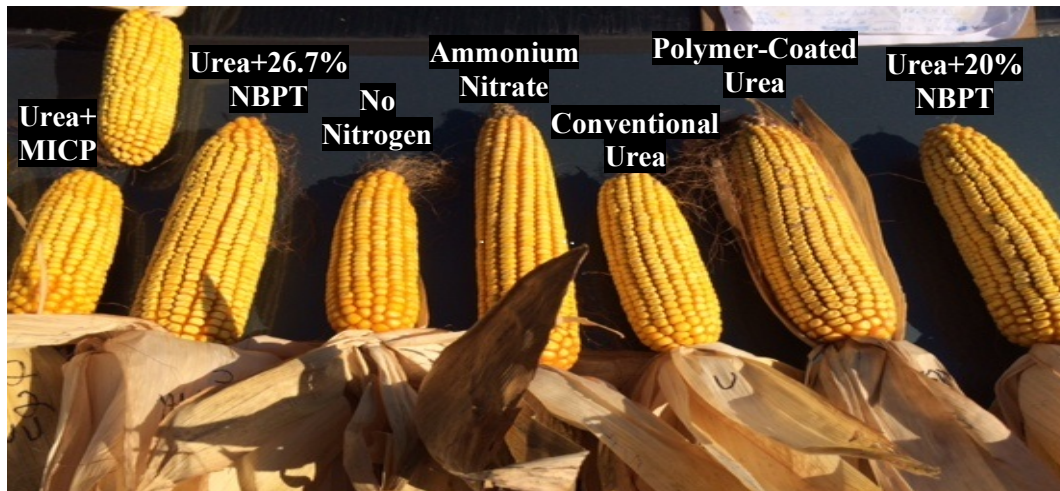


Figure 2. Corn ears from the experiment illustrating nitrogen deficiency in the no nitrogen fertilizer and conventional urea treatments as compared to ammonium nitrate, urea + NBPT, polymer-coated urea, and urea + MICP treatments.

Notes: Nitrogen treatments are described in Table 2.

Notwithstanding the positive effects of urea + NBPT and PCU on net returns relative to conventional urea, the EE urea fertilizers produced \$53 per acre smaller net returns than AN on the average (**Figure 3**). Reduced yield with EE urea relative to AN was the primary factor explaining the lower profitability (**Figure 2**). The PCU and urea + NBPT treatments produced 29 fewer bushels of corn per acre on the average than AN.

Besides the differences in yields with AN and EE urea, prices of AN and conventional urea also influence the profitability of EE urea products. The largest price difference between AN and conventional urea that was observed between 2000 and 2015 was \$0.18 per pound of N. Assuming a price premium of \$0.18 per pound for AN relative to conventional urea, a yield reduction of less than 3 bushels per acre is required for urea + NBPT or PCU to have the same profitability as AN. Given that the two EE urea products yielded 29 fewer bushels of corn per acre on the average than AN, there is likely no price premium for AN where the profitability of the two fertilizer products will be the same.

Urea-containing fertilizers are usually surface broadcast without any incorporation into soil under no-tillage. Application rate of N fertilizer, soil pH, soil moisture and air temperature are among the key factors affecting ammonia volatilization loss with urea. High temperature and precipitation conditions are common in Tennessee at the time N is applied. Warm and moist conditions at application facilitate high ammonia volatilization loss from urea-containing fertilizers. On the other hand, AN has low ammonia volatilization loss relative to urea.

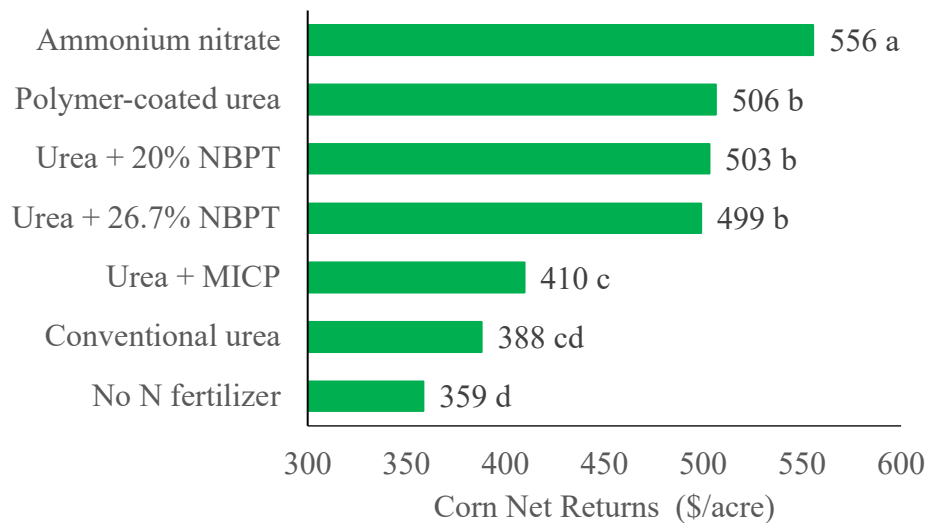


Figure 3. Net returns above nitrogen fertilizer cost for no nitrogen fertilizer, ammonium nitrate, conventional urea and enhanced efficiency urea fertilizers averaged over two nitrogen rates, three experiment locations (Jackson, Milan, Springfield) and three growing seasons (2013-2015).

Notes: Nitrogen treatments are described in **Table 2**. Net returns (corn price × corn yield – nitrogen fertilizer cost) for the nitrogen fertilizer treatments were averaged across the two nitrogen fertilizer rates (110 and 150 lb/acre) used in the experiment. An average corn price of \$4.06 per bushel for 2000 through 2015 was used to calculate net returns (<http://quickstats.nass.usda.gov/>). The estimated cost of each N fertilizer on a dollar per pound of elemental N basis is in **Table 2**. Prices are expressed in constant 2015 dollars to eliminate the effects of price inflation. Letters after net return for each fertilizer treatment that are different from each other indicate a statistically significant net return difference from the net returns of the other nitrogen fertilizer treatments. Data Source: Zhou et al. (2018).

Urea + NBPT and PCU provided more N nutrition to the crop than conventional urea, but it still provides less N nutrition to the crop than AN. The aforementioned factors help explain why the amended urea products did not perform as well as AN in the experiment. AN appears to be the best N fertilizer for avoiding volatilization loss of N and is the most profitable N fertilizer option when it is surface applied in no-tillage corn. However, security concerns may limit the availability of AN as a source of N in no-tillage corn production.

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