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Is Lower Priced Urea a Bargain?

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Urea (46% N) and urea-ammonium nitrate (28% UAN) have typically been about $0.10 per pound of nitrogen (N) more expensive than anhydrous ammonia (AA). Recently, urea prices have fallen substantially to be competitive with AA and less expensive than UAN.[1] Lower prices have resulted in an interest among farmers in using urea instead of AA or UAN. ***Is this a good change to make, or not?***

Urea's main advantage over AA is it can be applied faster and with less disruption to the soil. More N must be applied to Indiana farmland this spring because fewer acres than usual received AA in the fall. With preference being given to timely planting, urea is being considered as a means to accelerate application. Urea is obviously less dangerous than AA to apply as well. Unfortunately in most situations urea is not as good a fertilizer N source as AA. Urea is often inferior to UAN when surface-applied but equivalent or slightly better than UAN when incorporated into the soil.

Ammonia Volatilization from Urea and UAN

Surface-applied urea can be converted to ammonia, which can be lost to the air. This process is called ammonia volatilization (AVOL). Under the worst of conditions up to 60% of the N in urea can be lost by AVOL. More commonly losses are 30% or less. Since half of 28% UAN is comprised of urea, AVOL losses from 28% UAN are typically about half that of urea.

Results of studies conducted on several no-till fields in Indiana illustrate the impact of AVOL on grain yield (Table 1). Nitrogen loss due to surface application of urea or 28% UAN reduced corn yield an average 16 and 21 bushels per acre in comparison to injected UAN and anhydrous ammonia, respectively. Ammonia volatilization losses could not be calculated from these studies but they likely ranged from 30 to 80 lb N/a. Typically AVOL losses are expected to be greater with urea than with 28%, but this did not hold true in these studies. More recent research in Illinois showed much greater yield reductions with broadcast urea than 28% UAN (Table 3).

[1] Based on a recent informal survey around Indiana, prices for urea, AA, and 28% UAN were $489, $807, and $378 per ton or $0.53, $0.49, and $0.68 per pound for urea, AA, and 28% UAN.

Table 1. The effect on grain yield of no-till corn by N sources and method of application in Indiana.[1]

Nitrogen fertilizer and application method	Average grain yield bu/acre at 15.5% water
Anhydrous ammonia injected	139
28% UAN injected	135
28% UAN surface	118
Urea surface	123

[1] Adapted from D.B. Mengel et al. 1982. Placement of nitrogen fertilizers for no-till and conventional. Agronomy Journal 74:515-518.

The most important factor affecting AVOL is the pH around the urea compound. The higher the pH, the higher the potential for AVOL. Unfortunately the hydrolysis of urea creates its own high pH environment, climbing above pH 9 on sandy soils or on crop residues. Thus, the soil's resistance to pH change, or buffer capacity, is the most important soil factor affecting AVOL when urea is left the soil surface. Soils high in clay content, cation exchange capacity and organic matter have high buffer capacity and therefore low AVOL. Sandy soils, low in cation exchange capacity and organic matter, have high potential for AVOL because of low buffer capacity. Likewise, crop residues have low buffer capacity. Thus no-till fields have higher AVOL than tilled fields. Although the initial pH of the soil and the presence of surface applied lime may have some impact on AVOL these factors are much less important than buffer capacity. Warm moist conditions promote urea N loss as well.

Banded versus Broadcast Applications of UAN

If urea must be left on the soil surface it is much better applied in a narrow band than broadcast. Banding allows more of the material to runoff residues and penetrate deeper into the soil. Banding also slows urea conversion to ammonia. In a two year study at two Ohio locations, corn following corn yielded 9 bushels per acre better with banded 28% UAN than broadcast UAN (Table 2). Banded 28% UAN application produced 5 to 6 bushels per acre more corn than broadcast applications in multi-location and -year studies in Illinois (Table 3).

Urease Inhibitors for Surface Application of Urea

The compound NBPT [N-(n-butyl) thiophosphoric triamide] (the active ingredient in AGROTAIN) delays the conversion of urea to ammonia, thereby reducing AVOL. The longer the urea remains in the urea form the more likely rainfall will occur and incorporate the urea into the soil. Four years of study at two locations in both corn-corn and corn-soybean rotation in southern Illinois showed a 19 bu/acre improvement in yield from adding NBPT to broadcast urea. Even so injected UAN yielded 23 bu/acre greater

than urea plus NBPT. NBPT delays urea conversion to ammonia for a week or two, not forever, so ammonia volatilization can still occur if rainfall does not occur while the NBPT is still active.

Table 2. Corn grain yields as affected by broadcast and banding of 28% UAN at 150 pounds of N per acre.[1]

Nitrogen fertilizer and application method	Average grain yield bu/acre at 15.5% water
No N	86
28% UAN surface broadcast	145
28% UAN surface banded	154

[1] Adapted from D.J. Eckert. 1987. UAN management practices for no-tillage corn production. Journal of Fertilizer Issues. Vol. 4:13-18.

Table 3. The effect urea-containing N sources, different methods of application, and a urease inhibitor (NBPT) on grain yield of no-till corn grown in southern Illinois. Nitrogen was applied at planting at 180 lb N/a for corn-corn and 140 lb N/a for corn-soybean rotations. Grain yield was averaged over 2 locations, 4 growing seasons, and corn-corn and corn-soybean rotations.[1]

Nitrogen fertilizer, with (+) or without NBPT	Application method	Average grain yield, bu/acre at 15.5% moisture
28% UAN	injected	148
28% UAN	surface broadcast	118
28% UAN +NBPT		124
28% UAN	surface banded	124
28% UAN +NBPT		131
Granular urea	surface broadcast	106
Granular urea +NBPT		125

[1] Adapted from E.C. Varsa et al., Evaluation of Nitrogen Management Practices in No-Till Corn Production. Verified 1/25/2009. http://www.cropsci.uiuc.edu/research/rdc/dixonsprings/proj_reports/eval_nitro_practices.cfm

Soil Incorporation Eliminates Ammonia Volatilization

The most effective way to eliminate AVOL is to place the urea into the soil at least an inch or two deep with a knife or coulter applicator. Incorporation of urea into the soil can also occur via rainfall or irrigation, but only prior to conversion to ammonia. With warm temperatures, 75 °F or higher, the incorporation window by rainfall may be as little as 24 hours. Cold temperatures, like those around wheat topdressing time, slow urea conversion so there is more opportunity for rain to move the urea into the soil via rainfall. This is why urea and UAN have been traditionally used for topdressing wheat with less concern for AVOL.

Incorporated Urea as a Spring or At-Planting Replacement for Anhydrous Ammonia

Even when incorporated into the soil, urea can at times be an inferior substitute for anhydrous ammonia. Urea converts faster to nitrate than anhydrous ammonia so it is susceptible to leaching and/or denitrification losses for a longer period of time than anhydrous ammonia. Results from an eight-year trial on a Crosby silt loam (a common soil type in central Indiana) illustrate this point (Table 4). Corn fertilized just prior to planting at 160 lb N/acre with incorporated urea yielded 15 bushels per acre less than that fertilized with anhydrous ammonia – indicating about a 30% greater loss of N with urea. Using a nitrification inhibitor, such as nitrapyrin (N-Serve) or dicyandiamide (DCD), with preplant urea can slow the conversion to nitrate and reduce N loss from leaching and denitrification.

Table 4. Urea can be an inferior fertilizer to anhydrous ammonia even when incorporated into the soil just prior to planting due to quicker conversion to nitrate and loss through leaching or denitrification. Results from an 8-year study conducted on a Crosby silt loam soil in Ohio[1].

Nitrogen rate	Anhydrous ammonia	Urea
lb/acre	Grain yield, bushels per acre	
0	56	
80	116	101
160	139	125
240	-----	139
320	-----	139

[1]Adapted from R.C. Stehouwer and J.W. Johnson. 1990. Urea and anhydrous ammonia management for conventional tillage corn production. Journal of Production Agriculture 3:507-513.

Leaching of Urea

Urea is a molecule without charge. It is neither attracted to the cation or anion exchange sites occurring in soil. Urea moves with the percolating water until it is converted to

ammonia or ammonium. Rainfall shortly after application can incorporate the urea into the soil and reduce ammonia volatilization losses, but occasionally high rainfall shortly after application of urea will result in its leaching from the rootzone in sandy soils. The amount of N lost from the rootzone is dependent on the percentage of N in the urea form, soil type, the amount of rainfall in relation to evapotranspiration, and the depth of the rootzone. Although this type of N loss is rare it is encountered occasionally.

Polymer-Coated Urea

Urea release from plastic-coated fertilizer particles depends on moisture diffusing through the coating into the particle, dissolving the urea inside the particle, and diffusion of the N solution out of the particle. Lack of moisture could limit N availability at times, particularly with surface applied fertilizers. Varying the thickness of the particle coating as well as mixing particles of different coating thickness controls the rate of N release. Increasing temperature increases the rate of N release. Polymer-coated urea is less susceptible to AVOL than uncoated urea because it accumulates on the soil surface more slowly and causes less of pH change around the particle.

Summary

Surface applied urea fertilizers can result in significant N being lost to the air as ammonia. Losses are more likely, and greater in magnitude, in no-till cropping systems and when temperatures are warm. Incorporate urea fertilizers into the soil whenever possible to reduce N loss to AVOL to negligible levels. Use a strong urease inhibitor (NBPT) with broadcast applications of urea fertilizers to reduce AVOL losses as well. Avoid preplant applications of urea fertilizers unless a nitrification inhibitor is used to slow the formation of nitrate-N which would be subject to leaching and denitrification.

Don't forget, this and other timely information about corn can be viewed at the Chat 'n Chew Café on the Web at http://www.kingcorn.org/cafe. For other information about corn, take a look at the Corn Growers' Guidebook on the Web at http://www.kingcorn.org.