EVALUATION OF NEW NITROGEN FERTILIZER TECHNOLOGIES FOR CORN

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ABSTRACT

Farmers today are faced with escalating fertilizer prices, especially for nitrogen (N). Gains in nitrogen use efficiency (NUE) can help offset these prices. Corn has a nitrogen use efficiency (NUE) of less than 50% on average. Fertilizer N losses can occur from leaching, volatilization, denitrification, and immobilization. Several new N technologies have recently appeared on the market in Illinois to reduce N loss potentials. The objectives of this study were to 1) evaluate the effects of new nitrogen fertilizer technologies on corn yields under no-tillage and conventional tillage systems for corn after corn, and 2) determine the N use efficiencies for these new nitrogen fertilizer technologies. Several N sources were evaluated at four to five locations annually across the state of Illinois over a three-year period. These sources included 1) urea, 2) liquid urea-ammonium nitrate (UAN), 3) urea + agrotain®, 4) UAN + agrotain, 5) UAN + agrotainplus® (agrotain plus a nitrification inhibitor), 6) UAN + 10% v/v CaTs® (calcium thiosulfate), 7) SuperU® (urea with agrotain and a nitrification inhibitor), 8) ESN® (polymer-coated urea), and 9) UAN sidedress injected. All of the above treatments were applied at planting, except for the sidedress UAN injected treatment. Treatments included each of the N sources above either incorporated or left on the surface under conventional tillage (CT), or left on the surface under no-tillage (NT) systems. Nitrogen rates of 60, 120, 180 and 240 lb N per acre were associated with each N source. The yield responses associated with N sources could be broken into wet locations (those with >13 inches rainfall over the 15 week period after fertilizer application), intermediate (from 10 to 13 inches) and dry locations (<10 in.). Nitrogen source effects were highly significant, especially at the wet locations. The dry fertilizer products tended to do better than the liquid products. With CT, the lower residue levels at the surface appeared to reduce N losses from volatilization and denitrification. With NT, there was a fair amount of N loss from surface applied urea or UAN, indicating volatilization losses, which was reduced significantly by the application of agrotain or SuperU. Sidedress injection of UAN or application of ESN also significantly reduced N losses and increased yields. It appears that many of the N sources in this study may provide significant improvements in N use efficiency, especially during wet years. These differences appear to be more important with NT than CT, but more research is needed.

NITROGEN USE EFFICIENCY AND N LOSSES

Corn has a nitrogen use efficiency (NUE) of less than 50% on average. This is primarily due to timing of N application versus when corn takes up and utilizes N. Fertilizer N is vulnerable to N losses after application if it's not immediately taken up by the corn plants. Corn, in general, only requires about 10% of its total N requirement before the V-6 growth stage. This leaves much of the applied fertilizer N subject to loss mechanisms, especially when converted to nitrates (which occurs fairly rapidly during the late spring season). Fertilizer N losses can occur from erosion, leaching, volatilization, denitrification, and immobilization. One of the best ways to reduce N losses is by proper timing and placement of N closer to the time when corn utilizes it most efficiently, but logistical and weather problems prevent, in many cases, the actual accomplishment of optimal timing.

There are many new technological advances on the market to reduce N losses. These include chemical inhibitors and physical barriers to slow the release of N into soil solution or to prevent the conversion of ammonium (NH_4^+) to nitrate (NO_3^-). In the ammonium form, the N is held by the negative charge associated with clay particles and organic matter. Nitrate, on the other hand, is not held by the soil and can be leached or denitrified. Inhibitors are also available that can prevent the release of ammonia gas (NH_3) from the breakdown of urea or urea-containing fertilizers applied on or near the soil surface.

NITROGEN SOURCES STUDY IN ILLINOIS

Several N sources were evaluated at four to five locations annually across the state of Illinois over a three year period. These sources included 1) urea, 2) liquid urea-ammonium nitrate (UAN), 3) urea + agrotain®, 4) UAN + agrotain, 5) UAN + agrotainplus® (agrotain plus a nitrification inhibitor), 6) UAN + 10% v/v CaTs® (calcium thiosulfate), 7) SuperU® (urea with agrotain and a nitrification inhibitor), 8) ESN® (polymer-coated urea), and 9) UAN sidedress injected. All of the above treatments were applied at planting, except for the sidedress UAN injected treatment. Treatments included each of the N sources above either incorporated or left on the surface under conventional tillage (CT), or left on the surface under no-tillage (NT) systems. Nitrogen rates of 60, 120, 180, and 240 lb N per acre were associated with each N source.

The locations are identified in Figure 1. The Dixon Springs (DSAC) and Belleville (St. Clair) sites included both conventional tillage (CT) and no-tillage (NT) systems, but fertilizer sources were only surface applied with the NT system. With NT, all of the UAN treatments were dribble applied in narrow bands on 30" row spacing. Quadratic equations were utilized to fit curves across N rates. These curves were used to calculate economic optimum N rates (EONR) based on average prices of individual N sources and corn grain values during the period of study. Yields at EONR were determined and N use efficiencies (NUE) were calculated as lb N per bu of corn yield at the EONR.

CORN GRAIN YIELDS

N sources had a significant impact on corn grain yields in 10 out of 14 site-years. ESN, Urea+Agrotain, and SuperU all significantly increased yields when surface applied with CT systems (Figure 2). Products with UAN base had lower yields than urea based products, perhaps related to the nitrate portion of UAN being more susceptible to leaching and denitrification losses. Sidedressing was less effective than other sources because of not being able to time the application optimally in some of the site-years.

The incorporation of N sources resulted insignificant differences compared to surface applications in only 3 of 14 site-years under CT systems. Nitrogen source by incorporation treatment interactions were significant in only 4 of 14 site-years. The N source effects on yields when incorporated were very similar to surface applied treatments (Figure 3). N rate effects were significant 14 of 14 site-years, but there were no significant N source x N rate interactions.

With NT, N sources and N rates were highly significant in 5 of 5 site-years, but there were no interactions. (*Note: NT fields are not the same as CT fields so direct comparisons should be done with caution.)* The most effective N sources with NT were ESN and UAN sidedress injected (Figure 4). Products containing Agrotain also produced higher grain yields than urea and UAN.

It appears that N losses were more prevalent with NT than CT systems. There was also an improved performance of incorporated ESN and SuperU in "wet" years (>13 in. rainfall during 15-week period after N sources applied), especially with ESN, which appears to effectively reduce losses of N, most likely from denitrification. Lower yields in "wet" years versus "dry" years are also an indication of significant N losses in "wet" years. There was a decreased performance of ESN when surface applied during "dry" years (<10 in. rainfall). This is most likely due to inadequate moisture availability to allow the full release of N from the ESN.

NITROGEN USE EFFICIENCY

ESN tended to have the best NUE across placement and tillage systems in that they required the least amount of fertilizer N per bu of corn yield (Figures 5 and 6). NUE was higher (i.e. more N required per bushel of yield) for NT than CT, as expected, since N products were surface applied with greater potential for volatilization losses, especially in the presence of high residue levels. This higher residue would also lead to higher soil moisture retention and increased potential for denitrification. With CT, incorporation of N sources did not appreciably improve NUE over surface applications. It appears with CT that the lower residue levels at the surface reduces N losses from volatilization and denitrification compared to NT.

Figure 1. Locations of N Sources Study in Illinois.

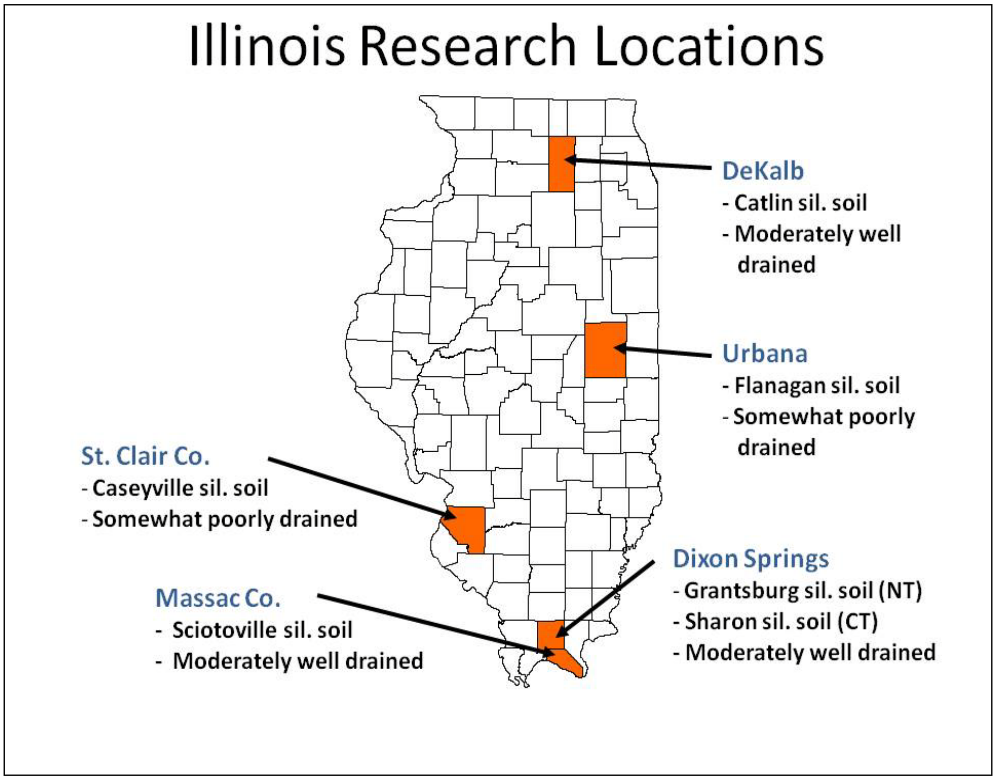

Figure 2. Effects of Surface Applied Nitrogen Sources on CT Corn Grain Yields.

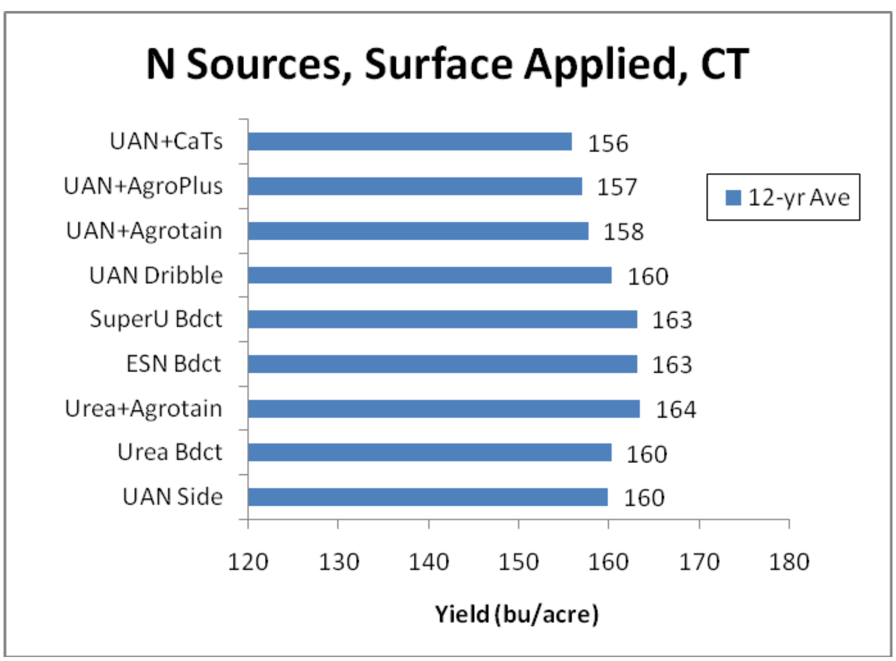

Figure 3. Effects of Incorporated Nitrogen Sources on CT Corn Grain Yields.

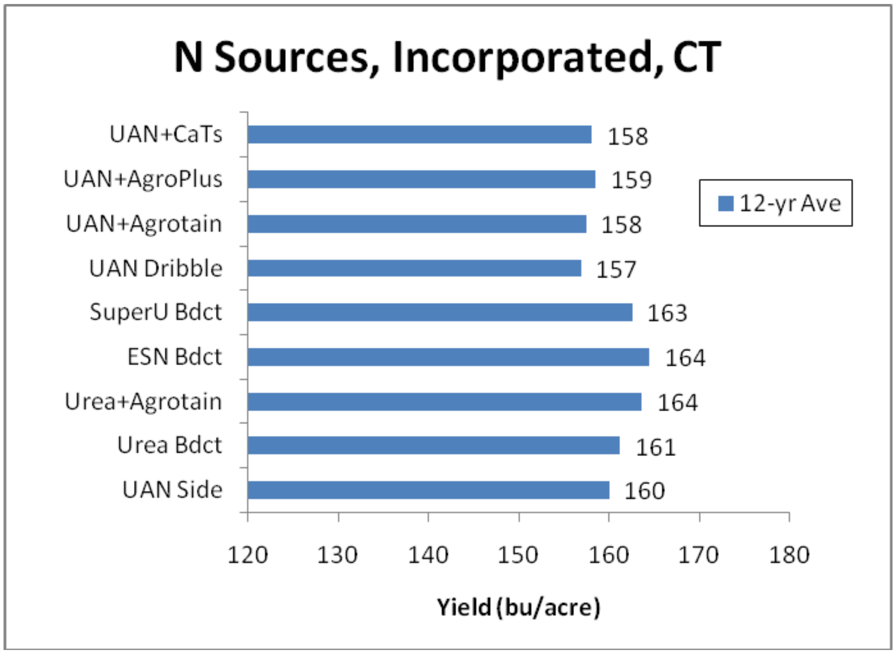

Figure 4. Effects of Surface Applied Nitrogen Sources on NT Corn Grain Yields.

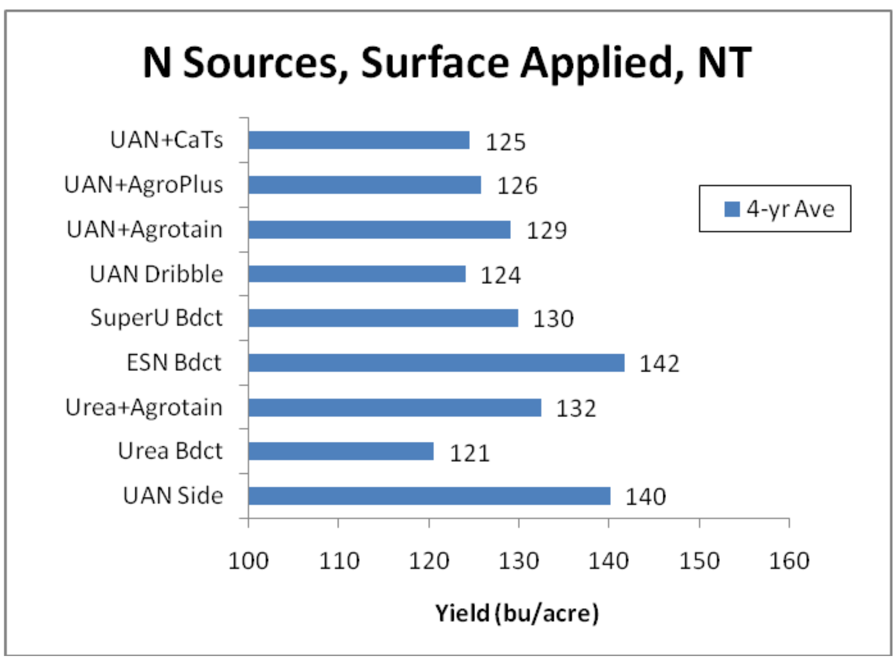

Figure 5. Effects of Incorporated Nitrogen Sources on CT Corn NUE.

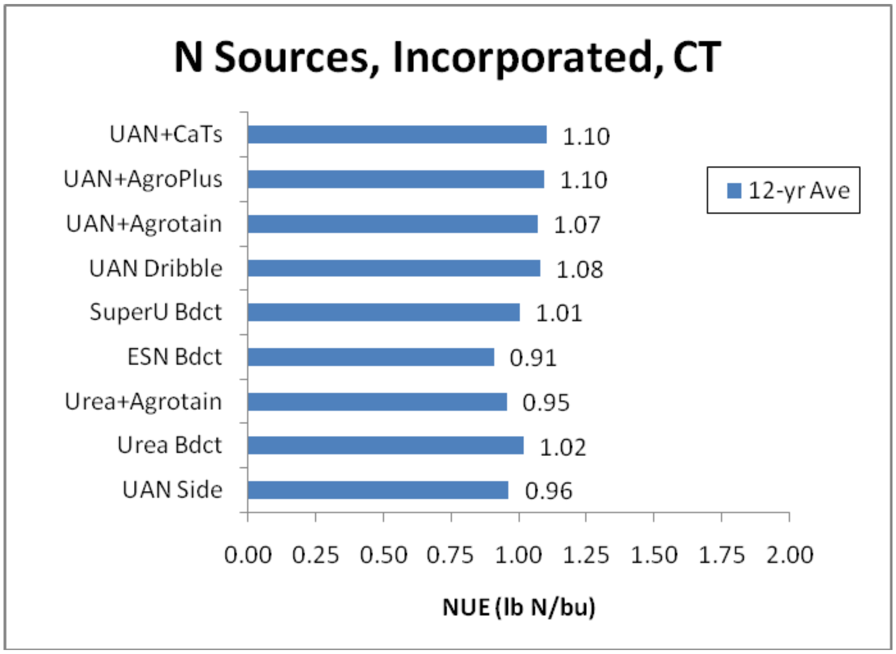

Figure 6. Effects of Surface Applied Nitrogen Sources on NT Corn NUE.